PATENT COOPERATION TREATY

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Commissioner
US Department of Commerce
United States Patent and Trademark Office, PCT
2011 South Clark Place Room CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 27 August 2001 (27.08.01)	
International application No. PCT/GB00/04635	**Applicant's or agent's file reference** 2020-P101-WO
International filing date (day/month/year) 05 December 2000 (05.12.00)	**Priority date** (day/month/year) 06 December 1999 (06.12.99)
Applicant CHAPMAN, Christopher et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

11 June 2001 (11.06.01)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was [ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer Juan CRUZ Telephone No.: (41-22) 338.83.38

Form PCT/IB/331 (July 1992)

GB0004635

Copy for the Elected Office (EO/US) PCT/GB00/04635

PATENT COOPERATION TREATY

869457

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

ATKINSON, Ralph
Atkinson Burrington
27-29 President Buildings
President Way
Sheffield S4 7UR
ROYAUME-UNI

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NOV 13 2001
Technology Center 2600

Date of mailing (day/month/year) 11 October 2001 (11.10.01)	
Applicant's or agent's file reference 2020-P101-WO	**IMPORTANT NOTIFICATION**
International application No. PCT/GB00/04635	**International filing date** (day/month/year) 05 December 2000 (05.12.00)

1. The following indications appeared on record concerning:

[X] the applicant [ ] the inventor [ ] the agent [ ] the common representative

Name and Address	State of Nationality	State of Residence
ELECTROTEXTILES COMPANY LIMITED	GB	GB
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[X] the person [X] the name [X] the address [ ] the nationality [ ] the residence

Name and Address	State of Nationality	State of Residence
SOUNDTOUCH LIMITED. Northdown Genesta Avenue Whitstable, Kent CT5 4EG United Kingdom	GB	GB
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

3. Further observations, if necessary:
The person in Box No. 2 will be the applicant for all designated States except US.

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[X] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland** Facsimile No.: (41-22) 740.14.35	Authorized officer Ki-Nam HA Telephone No.: (41-22) 338.83.38

09/869432

PATENT COOPERATION TREATY

PCT

REC'D 19 MAR 2002

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
2020-P101-WO		
International application No. PCT/GB00/04635	International filing date *(day/month/year)* 05/12/2000	Priority date *(day/month/year)* 06/12/1999
International Patent Classification (IPC) or national classification and IPC G06K11/18		
Applicant ELECTROTEXTILES COMPANY LIMITED et al.		

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APR 29 2002
Technology Center 2600

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 9 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 9 sheets.

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3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☒ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
11/06/2001	15.03.2002
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Schmidt, R Telephone No. +49 89 2399 2491

Form PCT/IPEA/409 (cover sheet) (January 1994)

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

6-26	as originally filed			
1-5	as received on	26/02/2002	with letter of	25/02/2002

Claims, No.:

1-20	as received on	07/03/2002	with letter of	06/03/2002

Drawings, sheets:

1/21-21/21	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☒ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)
   see separate sheet

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

   ☐ the entire international application.

   ☒ claims Nos. 35,36.

because:

☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):

☐ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. are so unclear that no meaningful opinion could be formed (*specify*):

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

☒ no international search report has been established for the said claims Nos. 35,36.

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

   ☐ the written form has not been furnished or does not comply with the standard.

   ☐ the computer readable form has not been furnished or does not comply with the standard.

IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees the applicant has:

☒ restricted the claims.

☐ paid additional fees.

☐ paid additional fees under protest.

☐ neither restricted nor paid additional fees.

2. ☐ This Authority found that the requirement of unity of invention is not complied and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is

☐ complied with.

☐ not complied with for the following reasons:

4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:

☐ all parts.

☒ the parts relating to claims Nos. 10-15,17,18,22-29,32-34.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	10-15,17,18,22-29, 33, 34
	No:	Claims	32
Inventive step (IS)	Yes:	Claims	10-15,17,18,22-29
	No:	Claims	32-34
Industrial applicability (IA)	Yes:	Claims	10-15,17,18,22-29,32-34
	No:	Claims	

2. Citations and explanations
see separate sheet

Preamble:

Reference is made to the following documents:

D1: WO 93 08540 A (STANFORD RES INST INT) 29 April 1993 (1993-04-29)
D2: DE 41 43 364 A (KOLLER ROMAN) 30 September 1993 (1993-09-30)
D3: EP-A-0 474 232 (SHARP KK) 11 March 1992 (1992-03-11)

Re Item I.

1. With the letter dated 06.03.2002 (received on 07.03.2002), the Applicant filed completely new claims 1-20 which are directed to an apparatus for processing a signal to determine a spatial position (cf. independent claim 1) and to a method of signal processing (cf. independent claim 11). The new claims have been filed without an indication of the basis for the amendments and said claims do not correspond to any claims in the original set of claims (claims 1-36). It is furthermore not apparent that there is a basis for these claims in the original figures or in the original description.
   Therefore, claims 1-20 filed with the letter dated 06.02.2002 introduce subject-matter which extends beyond the content of the application as filed, contrary to Article 34(2)(b) PCT.

   Hence, this report has been established as if the amendments to claims 1-20, filed with letter of 06.03.2002, had not been made. Accordingly, the observation made under Items III., IV. and V. refer to claims 1-36 of the application as originally filed.

Re Item VI.

This International Examining Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-4,16,21
   input device with touch and orientation sensing with respect to the ambient magnetic field

2. Claims: 5-9
   input device orientation sensing with respect to gravity
3. Claims: 10-15,17,18,22-29,32-34
   input device with sound actuated touch detectors
4. Claim : 19
   input device connected to a computer switching between text and graphical mode
5. Claim : 20
   input device with rechargeable cell
6. Claims: 30,31
   spherical touch input device mapped to a three dimensional object

The prior art document D1 discloses a substantially spherical input device including touch-sensing means for generating position signals indicative of the position of touch events occurring on the surface of the object, electro-magnetically based orientation sensing means, and means for combining touch and orientation input data for transmission to a computer (cf. abstract; figure 1 and associated description).

This document therefore covers the inventive idea of independent claims 1, 16 and 21 and there is no STF (Special Technical Feature), as defined in Rule 13.2 PCT in these independent claims. The inventive idea of dependent claim 2 is also covered by the prior art document and there is no STF. The STF of the first subject can be found in claims 3 and 4, i.e. to include ambient magnetic field sensors, solving the objective problem to identify the rotation of the device about the magnetic north axis (cf. Fig. 19, step 1901).

The STF of subject 2 (depending claims 5 to 9) is that the orientation is sensed with respect to gravity using a mobile inductor core and three sensing cores.
The objective problem is to identify rotation of the device about the vertical axis (cf. Fig. 19, step 1903).

The STF of subject 3 (depending claims 10 to 15 and 22 to 29 and independent sets of claims 32 to 34) is that the sound produced by an object touching the surface is sensed.
The the objective problem solved by these claims is to detect the movement of a finger across the sphere (cf. page 8, lines 4-8).

The STF of subject 4 (depending claim 19) is that the computer is able to switch between graphical and text mode.
The objective problem is to use the input device for text and graphic input.

The STF of subject 5 (depending claim 20) is that there is an inductive loop for recharging the cell of the input device. The objective problem is to provide wireless charging of the internal power supply.

The STF of subject 6 (independent claims 30 and 31) is that a mapping is generated from the input sphere to a three-dimensional object model.
The objective problem is to manipulate three-dimensional objects.

The above analysis shows that the STFs of the different groups of inventions are not the same. A comparison of the objective problems related to the different groups of inventions all seen in the light of the description and drawings of the application shows that they are all different and have no corresponding technical effects. Consequently the STFs of the different inventions do not correspond and the requirements of Unity of Invention (Rule 13.2 PCT) are not fulfilled.

Re Item V.

1. The prior art document D1 discloses a substantially spherical input device including touch-sensing means for generating position signals indicative of the position of touch events occurring on the surface of the object, electro-magnetically based orientation sensing means, and means for combining touch and orientation input data for transmission to a computer (cf. abstract; figure 1 and associated description).

   This document therefore covers the inventive idea of independent device claims 1 and 16 and the corresponding method claim 21. Hence, said claims do not meet the requirements of Article 33 PCT.

2. Dependent claim 10 adds to claim 1 the feature that said sensing means comprises a plurality of sound transducers. Similarly, dependent claim 17 adds to claim 16 that said touch sensing means comprises a plurality of microphones and

dependent claim 22 adds to claim 21 the feature that said sensing means includes acoustic transducer means. Corresponding features are not disclosed or suggested by D1.

Hence, the objective problem solved by these claims is to detect the movement of a finger across the sphere (cf. page 8, lines 4-8).

Documents D2 or D3 teach the use of sound transducers or microphones in touch sensing devices (cf. D2, column 1, line 67 - column 2, line 1; D3, page 5, lines 49/50). However, the teachings of both documents do not appear to lead in an obvious manner to the present invention as defined by claims 10, 17 or 22. The most important reason is that both documents exclusively deal with touch sensing on simple two-dimensional rectangular surfaces and do not contain any hints that this general sensing principle could be applied in the much more complex situation of a 3-dimensional surface. D2 furthermore teaches that a specific surface structure has to be provided in order to get acoustical signals which can be used to determine positional information (cf. figures 1a/c and associated description: "Riffellinien/Stoppelprofil"). Such specific surface structures cannot be easily provided on a spherical object like the present input apparatus. As regards D3, it has to be noted that the whole mathematical treatment of the position calculation requires an in-plane arrangement of the touch surface and all of the sensors so that none of the equations given in D3 is applicable in a 3-dimensional case.

Therefore, claims 10, 17 and 22 are considered to comprise novel and inventive subject-matter.

The subject-matter of claims 11-15, 18-20 and 23-29 is novel and inventive since these claims depended on one of claims 10, 17 or 22.

3. Independent claims 32 and 34 are essentially directed to a method of supplying positional information to a computer by detecting sound generated on a touched surface by acoustic transducer means. Their subject-matter appears to be at least clearly suggested by each of documents D2 (cf. column 1, line 35 - column 3, line 63) or D3 (cf. abstract and page 5, lines 49/50).

Therefore, independent claims 32 and 34 (as well as dependent claim 33) do not meet the requirements of Article 33 PCT.

Processing Signals to Determine Spatial Positions

The present invention relates to an apparatus for processing a signal to determine a spatial position, comprising signal input means, processing means and the memory means, wherein said processing means receives input signals from said input means and produces an output signal indicative of a spatial position by executing instructions read from said memory means. The present invention also relates to a method of signal processing, in which an interaction at a spatial position produces an input signal, and said signal is processed to produce an output signal indicative of said spatial position.

Apparatus for processing a signal to determine a spatial position is described in DE 4 143 364 in which the amplitude of signals derived from a microphone are analysed. As the amplitude of a signal increases, it is possible to process the signal to determine that a contact position is moving towards the microphone. A bearing on the movement may be obtained by combining the outputs from several microphones and a high level of resolution may be obtained by counting the number of impacts made with the relief pattern created upon a surface. In a more complex mode of analysis, relevant when a contact stylus is moving more quickly, sidebands are processed that are created by mixing the natural resonance of the stylus with the impact rate of the relief pattern.

A transformation of the signal produced is performed to the extent that the sample amplitudes are considered. Further transformations are performed when looking at sidebands, that may be considered as performing an integration. However, the transformed signal only gives information that

can be used in a linear equation to obtain position. Consequently, this limits the application of the procedure and creates a further requirement to the effect that a surface requires a particular relief pattern is required.

A photocopier control panel is described in EP 0 474 232 that utilises time delay of sound signals created by touching between at least three microphones. At least two microphones are required to obtain any data at all given that the delay of arrival is given by subtracting the absolute times.

A problem with these known techniques is that they rely upon substantially linear signal processing and as such their application to spatial position detection upon a surface is limited.

According to a first aspect of the present invention, there is provided apparatus of the aforesaid type, characterised in that the memory means stores a plurality of signal templates; the processing means processes an input signal to produce transform data that conveys a characteristic of an input signal that is correlated to an active spatial position; the processing means compares the transform data with stored templates to produce a similarity score for each of the templates; and the processing means interpolates a plurality of the similarity scores to produce the output data identifying the active spatial position.

Thus, the present invention addresses the problem of non-linearities with respect to the surface qualities. It does not require additional aides such as the provision of a relief pattern on the surface. Consequently, the inclusion of templates allows any surface system to be modelled irrespective of its inherent non-linearity. Furthermore, the inclusion of non-linearities of this type create particular problems when attempts are being made to track

movement.

In a preferred embodiment, the apparatus includes a plurality of transducer means wherein each of said transducer means is configured to produce an input signal and steps performed by said processing means are repeated to identify a plurality of active spatial positions.

The invention will now be described by way of example only, with reference to the accompanying drawings, of which:

Figure 1 shows a sensor and a computer terminal;

Figures 2 and *3* detail construction of the sensor shown in *Figure 1*, including microphones and a sensor core;

Figure 4 details components of the sensor core shown in *Figure 3*, including analogue to digital converters, orientation sensors and a digital signal processor;

Figure 5 details the digital signal processor shown in *Figure 4*;

Figure 6 details one of the analogue to digital converters shown in *Figure 4*;

Figure 7 details a frequency domain analysis of audio data recorded from one of the microphones shown in *Figure 2*, in response to a first type of touch event;

Figure 8 details a time domain analysis of audio data recorded from two of the microphones shown in *Figure 2*, in response to a second type of touch event;

Figure 9 details steps executed on the digital signal processor shown in *Figure 4*, including a step of identifying a drag position, a step of identifying a hit position and a step of identifying sphere orientation;

Figure 10 details the step of identifying a drag position shown in *Figure 9*, including a step of correlating with templates and a step of identifying intersecting arcs;

Figure 11 details templates that are used in the step of correlating with templates shown in *Figure 10*;

Figure 12 illustrates the step of identifying intersecting arcs shown in *Figure 10*;

Figure 13 details the step of identifying a hit position shown in *Figure 9*;

Figure 14 details the orientation sensors shown in *Figure 4*, including a magnetic field sensor and a gravitational field sensor;

Figures 15 and *16* detail the magnetic field sensor shown in *Figure 14*;

Figures 17 and *18* detail the gravitational field sensor shown in *Figure 14*;

Figure 19 details the step of identifying sphere orientation shown in *Figure 9*;

Figures 20 and *21* detail construction of a charger and receiver unit for use with the sensor and computer terminal shown in *Figure 1*;

Figure 22 details components of the computer terminal shown in *Figure 1*, including a memory;

Figure 23 details contents of the computer memory shown in *Figure 22*;

Figure 24 summarises steps performed by the computer terminal shown in *Figure 1*, including a step of calibrating the sensor and a step of using the sensor;

Figure 25 details the step of calibrating the sensor shown in *Figure 24*;

Figure 26 details the step of using the sensor shown in *Figure 24*, including a step of processing touch event data; and

Figure 27 details the step of processing touch event data shown in *Figure 26*.

A computer terminal is illustrated in *Figure 1*. The computer terminal **101** comprises a high resolution display panel **102** and standard personal computer circuitry. The display **102** is the only visible part of the computer. The components of the computer are built in to the display housing. The computer is connected to the internet, and provides access to media of many different types, including audio, video, applications such as word processors, and so on. This highly varied functionality is provided by the combination of an internet browser software application and a graphical user interface environment such as X-Windows. This combination of technologies, both hardware and software, with information presented through a graphical display, may be considered as a first kind of computer generated environment. A second kind of computer generated environment is one in which a three dimensional virtual world is presented on a two dimensional screen, and various forms of user input enable the user to navigate, as if physically present, in the virtual space. Virtual spaces of this type are presently used widely in games, but also for serious business applications, such as the representation of bug tracking in complex computer software development. Three dimensional virtual worlds are widely believed to be the future of the Internet, though at the present time, specific interpretations of this vision have not been sufficiently developed to provide practical engineering proposals.

Claims

1. Apparatus for processing a signal to determine a spatial position, comprising

signal input means (**401**, **402**), processing means (**507**), and memory means (**504**, **505**, **506**), wherein said processing means receives input signals from said input means and produces an output signal indicative of a spatial position by executing instructions read from said memory means, characterised in that:

said memory means (**504**) stores a plurality of signal templates;

said processing means (**507**) processes an input signal to produce transformed data that conveys a characteristic of said input signal that is correlated to an active spatial position;

said processing means (**507**) compares said transformed data with said stored templates to produce a similarity score for each of said templates; and

said processing means interpolates a plurality of selected similarity scores to produce said output data identifying said active spatial position.

2. Apparatus according to claim **1**, including a plurality of transducer means wherein each of said transducer means is configured to produce an input signal, and steps performed by said processing means are repeated to identify a plurality of active spatial positions.

3. Apparatus according to claim **2**, wherein said processing means combine said plurality of spatial positions to identify a location of a common source.

4. Apparatus according to claim **1**, wherein said processing means processes an input signal to produce said transformed data by identifying characteristic frequency-related components of an active input signal.

5. Apparatus according to claim **1**, including surface means, wherein said signal input means includes acoustic transducer means and said acoustic transducer means are arranged to generate active input signals in response to movements made against said surface means.

6. Apparatus according to claim **5**, wherein said surface means is finger-operable.

7. Apparatus according to claim **6**, wherein said surface means is curved.

8. Apparatus according to claim **7**, wherein said curved surface is fully enclosed.

9. Apparatus according to claim **8**, wherein said fully enclosed curved surface is substantially spherical.

10. Apparatus according to claim **5**, wherein said surface and said transducers are remotely located from said processing means.

11. A method of signal processing, in which an interaction at a spatial position produces an input signal, and said input signal is processed to produce an output signal indicative of said spatial position, characterised by the steps of:

processing an active input signal to produce transformed data that conveys a characteristic of said input signal that is correlated to an active spatial position;

comparing said transformed data with a plurality of stored data templates of known spatial position;

producing a similarity score for each of said template comparisons;

interpolating selected similarity scores to identify a value for said active spatial position; and

producing an output signal in response to said interpolated position value.

12. A method according to claim **11**, wherein said spatial position is a distance from a transducer from which said input signal is derived.

13. A method according to claim **11**, including the step of identifying a plurality of said spatial positions in response to respective signals derived from a plurality of respective transducer means.

14. A method according to claim **13**, wherein a plurality of transducer means receive inputs form a common location and said location

is identified by combining said plurality of spatial positions.

15. A method according to claim **11**, wherein said transform data is generated by an identifying characteristic of frequency-related components of said signal.

16. A method according to claim **11**, wherein said active input signal is generated by transducing means in response to the sound of a movement made against a surface.

17. A method according to claim **16**, wherein said movement is that of a user's fingertip.

18. A method according to claim **16**, wherein said movement is made against a curved surface.

19. A method according to claim **16**, wherein said movement is made against a fully enclosed curved surface.

20. A method according to claim **19**, wherein said fully enclosed curved surface is substantially spherical.

DSW

ENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 2020-P101-WO	**FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/GB 00/ 04635	International filing date *(day/month/year)* 05/12/2000	(Earliest) Priority Date *(day/month/year)* 06/12/1999
Applicant ELECTROTEXTILES COMPANY LIMITED et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 7 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

[ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

[ ] contained in the international application in written form.

[ ] filed together with the international application in computer readable form.

[ ] furnished subsequently to this Authority in written form.

[ ] furnished subsequently to this Authority in computer readble form.

[ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

[ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [X] **Certain claims were found unsearchable** (See Box I).

3. [X] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

[X] the text is approved as submitted by the applicant.

[ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

[X] the text is approved as submitted by the applicant.

[ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

[X] as suggested by the applicant.

[ ] because the applicant failed to suggest a figure.

[ ] because this figure better characterizes the invention.

[ ] None of the figures.

Form PCT/ISA/210 (first sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

ernational application No.
PCT/GB 00/04635

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [ ] Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. [X] Claims Nos.: 35,36
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. [X] As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[X] No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 35,36

Rule 6.2(a) PCT: Claim refering to other parts of the application

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-4,16,21

   input device with touch and orientation sensing

2. Claims: 5-9

   input device orientation sensing with respect to gravity

3. Claims: 10-15,17,18,22-29,32-34

   input device with sound actuated touch detectors

4. Claim : 19

   input device connected to a computer switching between text and graphical mode

5. Claim : 20

   input device with rechargeable cell

6. Claims: 30,31

   spherical touch input device mapped to a three dimentional object

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 00/04635

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G06K11/18 G06K11/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 93 08540 A (STANFORD RES INST INT) 29 April 1993 (1993-04-29) page 2, line 16 - line 38 page 3, line 36 -page 4, line 14 page 4, line 32 -page 5, line 13; claims 1,2,10; figures 1,4 ---	1-4,16, 21
A	WO 97 39401 A (MILGRAM PAUL ;ZHAI SHUMIN (US)) 23 October 1997 (1997-10-23) page 6, line 12 - line 24 page 10, line 21 - line 23; claims 1-3,14-17; figures 1,8 ---	1,2,16, 21
A	US 4 851 775 A (KIM NAM H ET AL) 25 July 1989 (1989-07-25) cited in the application the whole document ---	3,4,7,8

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

7 March 2001

Date of mailing of the international search report

14. 03. 01

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Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	PATENT ABSTRACTS OF JAPAN vol. 1998, no. 13, 30 November 1998 (1998-11-30) & JP 10 213405 A (GOTO TADATOSHI), 11 August 1998 (1998-08-11) abstract	5-8
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A	the whole document	10-15, 17,18, 22-29
A	EP 0 474 232 A (SHARP KK) 11 March 1992 (1992-03-11)	10,11, 13-15, 17,22, 32,34
	page 4, line 57 -page 5, line 11 page 5, line 41 - line 43; figures 1,2	
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International Application No
PCT/GB 00/04635

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 00/04635

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(25) Filing Language: English

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Published:
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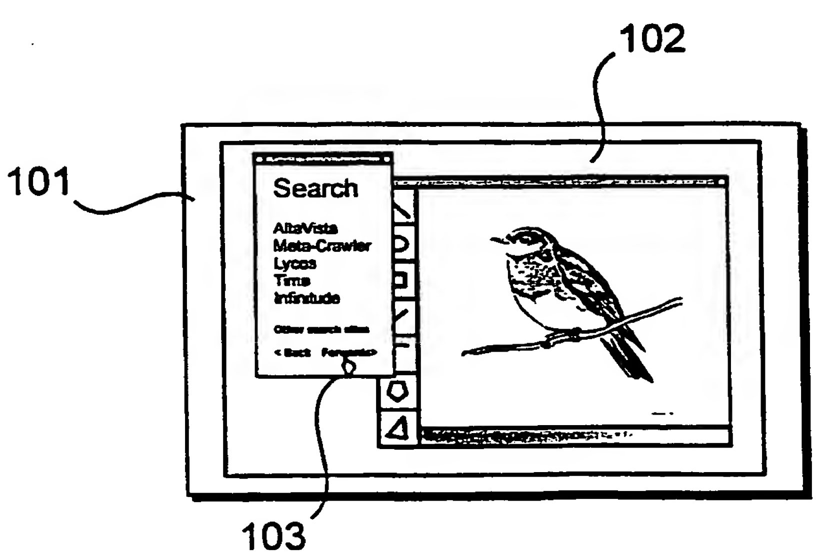
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: INPUTTING DATA



(57) Abstract: An apparatus is disclosed for supplying input signals to a computer. A sensor having the form of a sphere has a touch sensitive surface for generating position data for touch events. The sensor includes orientation sensors that determine rotation with respect to the earth's magnetic and gravitational fields. Orientation data may be combined with position data to interpret the orientation of touch events on the surface with respect to the computer's display. Cursor movement or text may be generated from touch events. Preferably the sphere has a roughened surface that generates sound when touched. Position data is generated by processing signals from microphones under the sphere's surface.

WO 01/43063 A1

Inputting Data

Field of the Invention

The present invention relates to an input apparatus for generating control signals for a computer.

Introduction to the Invention

The tasks performed by the operator of a computer have defined the devices through which input data is generated. In the case of a personal computer, a keyboard and a mouse are used.

Design and operation of computer peripherals maintains the difference between computers and other equipment such as radio, hi-fi and television. The requirement of a keyboard and mouse is becoming increasingly perceived as a major barrier to the wider use of computers in a much broader range of activities.

An example is the emergence of MP3 and other related audio compression standards. These provide high quality compression of audio data. Most radio stations around the world are now able to broadcast over the internet, in additional to their traditional location in the electromagnetic spectrum. Furthermore, it has become possible to store an entire CD collection on a low cost computer hard disk. However, the computer, in its present form, is not considered as a serious alternative to radio or hi-fi devices. A similar situation exists with video data. The preferred viewing device, except when editing, is a traditional television set.

Computers are increasingly capable of receiving and manipulating many different media types within a common, easily used, computer-generated environment. However, the method of supplying input to the

computer terminal has restricted the wider use of this technology. The keyboard and mouse are best operated at a desk, and this prevents computers from being considered as replacements for a broad range of conventional electronic equipment. As computer and internet technology develops, increasingly the restrictions placed upon it are in the way the user interacts with computers through an input device.

The digitisation of graphic design, video and film editing has led to the development of improved devices for interaction with image data. The most widely used of input devices in this context is the graphics tablet, which is operated in the manner of a pencil-with-paper. On a large graphics tablet, it is possible to provide an area having the function of a keyboard, and this may be operated to generate occasional text where this required.

In three-dimensional computer modelling, no single preferred peripheral device has emerged. Several systems are known, optimised for particular applications. An example of this is radio tracking, which provides three dimensions of position and three dimensions of rotation. In a virtual reality application, a radio receiver is fixed to a users head-mounted display, and the position information obtained by analysing data from a fixed transmitter is used to determine stereoscopic images for the users eyes. The images are updated so as to provide an appropriate view for the angle and position of the user's head. Similar devices may be used to track the position of a hand, including devices that use ultrasound to determine orientation. Hand gestures resulting from finger movement may be tracked using a data glove. However, none of these devices is suitable for replacing a keyboard or mouse due to the requirement to suspend the devices in space in order to generate position data in the third dimension.

Graphics tablets and three dimensional input devices may be suitable

for replacing the keyboard and mouse in certain applications. However, their high cost, and other practical considerations, make them unsuitable replacements for the widespread, low cost and ubiquitous keyboard and mouse of the personal computer.

Summary of the Invention

It is an aim of the present invention to provide an improved input apparatus for supplying control signals to a computer.

Brief Description of the Drawings

Figure 1 shows a sensor and a computer terminal;

Figures 2 and *3* detail construction of the sensor shown in *Figure 1*, including microphones and a sensor core;

Figure 4 details components of the sensor core shown in *Figure 3*, including analogue to digital converters, orientation sensors and a digital signal processor;

Figure 5 details the digital signal processor shown in *Figure 4*;

Figure 6 details one of the analogue to digital converters shown in *Figure 4*;

Figure 7 details a frequency domain analysis of audio data recorded from one of the microphones shown in *Figure 2*, in response to a first type of touch event;

Figure 8 details a time domain analysis of audio data recorded from two of the microphones shown in *Figure 2*, in response to a second type of touch event;

Figure 9 details steps executed on the digital signal processor shown in *Figure 4*, including a step of identifying a drag position, a step of identifying

a hit position and a step of identifying sphere orientation;

Figure 10 details the step of identifying a drag position shown in *Figure 9*, including a step of correlating with templates and a step of identifying intersecting arcs;

Figure 11 details templates that are used in the step of correlating with templates shown in *Figure 10*;

Figure 12 illustrates the step of identifying intersecting arcs shown in *Figure 10*;

Figure 13 details the step of identifying a hit position shown in *Figure 9*;

Figure 14 details the orientation sensors shown in *Figure 4*, including a magnetic field sensor and a gravitational field sensor;

Figures 15 and *16* detail the magnetic field sensor shown in *Figure 14*;

Figures 17 and *18* detail the gravitational field sensor shown in *Figure 14*;

Figure 19 details the step of identifying sphere orientation shown in *Figure 9*;

Figures 20 and *21* detail construction of a charger and receiver unit for use with the sensor and computer terminal shown in *Figure 1*;

Figure 22 details components of the computer terminal shown in *Figure 1*, including a memory;

Figure 23 details contents of the computer memory shown in *Figure 22*;

Figure 24 summarises steps performed by the computer terminal shown in *Figure 1*, including a step of calibrating the sensor and a step of using the sensor;

Figure 25 details the step of calibrating the sensor shown in *Figure 24*;

Figure 26 details the step of using the sensor shown in *Figure 24*, including a step of processing touch event data; and

Figure 27 details the step of processing touch event data shown in *Figure 26*.

Detailed Description of The Preferred Embodiments

A computer terminal is illustrated in *Figure 1*. The computer terminal **101** comprises a high resolution display panel **102** and standard personal computer circuitry. The display **102** is the only visible part of the computer. The components of the computer are built in to the display housing. The computer is connected to the internet, and provides access to media of many different types, including audio, video, applications such as word processors, and so on. This highly varied functionality is provided by the combination of an internet browser software application and a graphical user interface environment such as X-Windows. This combination of technologies, both hardware and software, with information presented through a graphical display, may be considered as a first kind of computer generated environment. A second kind of computer generated environment is one in which a three dimensional virtual world is presented on a two dimensional screen, and various forms of user input enable the user to navigate, as if physically present, in the virtual space. Virtual spaces of this type are presently used widely in games, but also for serious business applications, such as the representation of bug tracking in complex computer software development. Three dimensional virtual worlds are widely believed to be the future of the Internet, though at the present time, specific interpretations of this vision have not been sufficiently developed to provide practical engineering proposals.

In order to interact with a computer generated environment, a user must have convenient control over the position and orientation of their viewpoint. In the case of a conventional computer desktop environment, navigation involves convenient movement of a cursor or pointer **103**. Furthermore, text entry is required also. The amount of text entry required depends upon the application, but these two requirements, movement and text input, can be seen as fundamental to any general purpose computer environment, of any type.

The present day windows-based desktop environment was developed over many decades, and has evolved as a result of the availability of the mouse, along with a keyboard for text entry. At the time of their development, windows and mouse -based graphical user interface environments were not considered stressful to use. However, their use on every desktop, and near constant use daily in the workplace, has resulted in various stress-related symptoms, including Repetitive Strain Injury (RSI) and Carpal Tunnel Syndrome. That these injuries exist indicates that the conventional computer interface is at least mildly stressful to use, and that better methods of input will enable worker productivity to be increased as well as potentially opening up general purpose computers to increased daily use in non-stressful leisure-related activities.

An improved computer input device is shown in *Figure 1.* The computer input device **104** is spherical in shape. The sphere is approximately six centimetres in diameter. Usually, the sphere **104** is supported in the left hand, as shown, while a finger of the right hand traces across its surface in order to affect and control the position of the pointer **103** on the screen. The sphere **104** may be freely oriented in any degree, and movements of the finger are interpreted as being made with respect to

the screen **102**, rather than locally with respect to the surface of the sphere **104**. In this way, the user can freely rotate and orient the sphere, while performing finger-movements on any part of its surface, which may then be interpreted as being performed in the space of the computer-generated environment, rather than in the physical environment of the input device **104** itself. This removes a layer of abstraction from the computer interface, and enables a language of interactions to be developed that is inherently intuitive and fast.

In a two-dimensional desktop environment, the sphere presents an infinite surface over which the mouse pointer may be moved, thus mimicking mouse movements, but accomplished entirely with movements of the fingers, and including rotations of the sphere, or ball, **104**, by the left hand when necessary.

Deliberate movements of a finger across the surface are interpreted as a movement of the pointer in the computer-generated environment. Manipulations of the left hand generate touch event signals that can be ignored. The tracing of a finger across the surface of the sensor **104** is a first method of generating input data. Using a traditional computer mouse, a click or double click is used to signify an action that is performed with respect to the location of the pointer on the screen **102**. This is achieved by a tap or double tap on the sensor **104**, regarded as a hit. The position of the hit may be used to determine the nature of the command to be performed. However, a far wider variety of events is possible with the sphere **104**.

The sphere **104** may be used to enter text characters. To signify a change from the previously described method of graphical operation, the sensor is hit, fairly hard, anywhere on its surface. Thereafter, movements of a finger on the surface may be interpreted as alphanumeric characters.

Text entry may be performed one character at a time, using character recognition. Alternatively, for high speed text entry, a form of shorthand writing may be used.

The sphere **104** has a slightly roughened surface. Friction between a finger and the surface, as the fingertip is moved across it, results in the generation of random acoustic noise. The friction-generated noise is analysed in order to determine the position of a finger-drag event of this type. The arrangement of microphone sensors to perform detection of noise generated in this way is shown in *Figure 2*. The shell of the sphere comprises three millimetre thick silicone rubber, and this is covered by a fine nylon felt that provides a suitable noise-generating surface. Directly beneath the silicone rubber shell, arranged equidistant from each other, are four microphones **201**, **202**, **203** and **204**. These have a frequency range substantially equal to that of human hearing, and can be general purpose audio microphones. Each microphone may be considered as being at the centre of a face of a three-sided pyramid, or regular tetrahedron. The angle made between any two microphones at the centre of the sphere is approximately one hundred and ten degrees.

Signals received by an individual microphone may be analysed to identify the proximity of a noise-generating drag event, and the results of an analysis of this type from two or more microphones are combined to identify the location of the touch event on the surface of the sphere.

Further details of the construction of the sphere **104** are shown in *Figure 3*. During manufacture, the silicone rubber shell is created in two halves **301** and **302**. A central core **303** contains the circuitry of the sensor. Between the core **303** and the silicone rubber shell is a layer of acoustically isolating and shock absorbant polyester fibre **304**. This construction firstly

ensures that microphones **201** to **204** are sufficiently acoustically isolated from each other, and that each microphone only receives sound directly from the silicone rubber shell. As a significant further advantage, however, this construction provides a very high level of shock-immunity, so that the sphere **104** may be handled extremely roughly without damage. The microphones **201** to **204** are embedded in moulded silicone rubber mountings in the shell itself.

The two halves **301** and **302** of the sphere **104** are combined using an acoustically homogeneous silicone rubber seal. The core **303** contains a rechargeable battery, and this must receive power externally when recharging is required. In order to avoid compromising the structural integrity of the surface by a wire connection, an inductive loop **305** provides contactless access to the recharging power source.

Circuitry contained within the central core **303** shown in *Figure 3* is detailed in *Figure 4*. A first stereo analogue to digital converter (A-D) **401** receives analogue audio signals from the first two microphones **201** and **202** a second stereo analogue to digital converter **402** receives analogue audio signals from the second two microphones **203** and **204**. A suitable analogue to digital converter is the CS53L32A, made by Cirrus Logic, available from http://www.cirrus.com. The converters **401** and **402** generate a multiplexed digital audio signal that is supplied to a digital signal processor (DSP) **403**. The digital signal processor is preferably a Motorola DSP56603, that includes arithmetic and memory circuitry suitable for audio signal analysis. Design data and other information about the DSP56603 is available from http://ebus.mot-sps.com.

Analysis of signals supplied to converters **401** and **402** results in touch event position signals being generated, and these are transmitted

digitally from a transmitter **404** to a receiver connected to the computer terminal 101. Positional signals are generated with respect to the terminal **101**, irrespective of any degree of rotation of the sensor **104**. This is facilitated by orientation sensors **405**. The signals from the orientation sensors define the orientation of the sphere **104** with respect to the screen **102**, and thereby enable calculations to be performed that effectively remove the orientation of the sphere from the interpretation of touch events made upon its surface. Said touch events are thereafter considered and interpreted with respect to the screen, regardless of the sphere's actual orientation. From the user's point of view, the sphere always looks and feels the same, and can rotate it and operate it without concern for its orientation.

In order to measure orientation of the sphere, the orientation sensors **405** characterise sensor orientation as a first rotation RM about a horizontal axis due to the Earth's magnetic field and a second rotation RG about a vertical axis due to the Earth's gravitational field. By combining these data items with data about the positions of touch events occurring on the surface of the sphere, it is possible to interpret user touch events on the sphere with reference to a standard space in which the computer terminal **101** is located. Thus, for example, a forward dragging movement of the finger towards the screen **101** will move the cursor upwards, regardless of the sphere orientation.

The core **303** includes a power management circuit **406**, that facilitates low power and shutdown modes for the DSP **403**, and other circuitry. The power manager **406** receives power from a rechargeable NiMH battery **407**, and also facilitates rectification and current regulation of recharging power supplied from the inductive loop **305**.

The digital signal processor **403** shown in *Figure 4* is detailed in *Figure 5*. Several data and address busses are present within the DSP, and these are summarised for the sake of clarity by a simplified wiring connection **501**. Timers **502** provide pulse width timing capabilities that are used to measure signals from the orientation sensors **405**. Input and output circuits (I/O) **503** provide several physical connections from the DSP to the other components in the core, including the A-D converters **401** and **402**. The program ROM and RAM **504** includes bootstrap instructions and control instructions for co-ordinating interface operations with other circuitry in the core **303**, and for performing real time signal analysis. An X data RAM and a Y data RAM **505** and **506** provide a pair of operands per instruction cycle to an arithmetic and logic unit (ALU) **507**. The ALU is thereby capable of fetching and multiplying two data operands from X and Y memory **505** and **506** in every instruction cycle. This arrangement facilitates efficient implementation of the processing algorithms that are required in order to determine the position of touch events on the surface of the sphere.

Each of the A-D circuits **401** and **402** comprise circuitry as shown in *Figure 6*. A first channel pre-amplifier **601** receives an unamplified audio signal from a microphone and increases its intensity to that which is suitable for digital to analogue conversion. An anti-alias filter **602** removes frequency components above half the sampling rate, so as to ensure that subsequent frequency analysis of audio data gives an accurate representation of the spectrum. The output from filter **602** is supplied to the left input of a stereo sixteen bit low power analogue to digital converter chip **603**. The sampling rate is 44.1kHz. Another channel is implemented for a second microphone using pre-amplifier **604** and anti-alias filter **605**. A

common multiplexed output is supplied from the A-D converter chip to the DSP **403**. Additional clock and word synchronisation signals have been omitted from this diagram for the sake of clarity.

An analysis of several seconds of audio data from a single channel is shown in *Figure 7*. The vertical axis represents time, and the vertical axis represents frequency. In this graph, the amplitude of a particular frequency component at a particular time is represented by density. The graph shows a plot of a signal that results from the movement of a finger across the surface of the sphere.

At the start of the plot **701** the fingertip is distant from the microphone. Sound waves reaching the microphone are primarily transverse waves, oscillating perpendicular to their direction of propagation. The silicone rubber filters high frequencies but has little effect on the low frequencies. Thus, the signal reaching the microphone, regardless of its actual amplitude, contains an indication of the distance due to the relative strengths of high and low frequencies. As the finger tip moves closer, higher frequencies increase, while the strength of the low ones remains substantially the same. As the fingertip becomes increasingly close to the microphone, at **703**, a completely new set of frequencies is added in the spectrum. This is due to longitudinal waves being transferred across the thickness of the silicone rubber from the fingertip, directly to the microphone. As the microphone is approached, there is a mixture of both longitudinal and transverse waves, as identified from the two distinct areas of the graph at **703** and **702**.

A final exceptional condition is reached when the fingertip is directly over the microphone. The high frequency components are generated by the friction between the edge of the finger and the roughened surface of the

sphere. However, when the finger is directly over the microphone, these high frequency components are masked, and the sound picked up by the microphone comes from the centre of an area of the fingertip alone. At **704**, a sudden loss of high frequencies occurs because these frequencies are damped by the area of the fingertip. The low frequencies exhibit a characteristic change, having a more balanced profile.

These changes provide a characteristic set of descriptions for finger dragging events that occur on the surface of the sphere. By comparing the outputs two or three channels at once, the position of a moving fingertip anywhere on the surface of the sphere **104** may be identified.

Hitting the sphere, to perform the equivalent of a mouse click, does not contain as much frequency data, and so a different type of analysis is used. The speed of transverse sound waves in the silicone rubber shell is in the order of only twenty metres per second. This makes it possible to discern a time difference for wavefronts arriving at different microphones. A pair of graphs resulting from a simultaneously digitised hit event are shown in *Figure 8*. Trace **801** is for the more distant microphone, and it can be seen that this commences a short period after the second trace **802**. The difference in initial characteristic wavefronts is in the order of two thousandths of a second. This provides a reasonably accurate source of position data. The traces **801** and **802** also exhibit differences in frequency content, which may be observed in the jaggedness of the second trace **802**, which is the microphone nearest to the hit event. Waveform **801** reaches a higher peak, due to the lack of damping provided by the finger over the point of impact just after the hit event has occurred. Several such characteristics may be analysed and the results combined so as to identify a touch event characteristic to an increased level of accuracy.

The main sequence of steps performed by the DSP **403** shown in *Figure 4* is summarised in the flow chart in *Figure 9*. At step **901** a frequency domain analysis is performed on each of the four channels of buffered audio data. At step **902** a question is asked as to whether a drag or a hit event has been observed in the data. It is possible that neither is identified, either due to lack of occurrence, or because a clear characteristic cannot be identified. If neither drag nor hit is present in the audio data, control is directed to step **905**. If a hit is observed, control is directed to step **904**, or, if a drag is observed, control is directed to step **903**. At step **903** the drag position is identified. At step **904** the hit position is identified.

At step **905** the sphere orientation is identified by analysing data from the orientation sensors **405**. At step **906** a question is asked as to whether any data needs to be transmitted to the computer. For example, if no touch event has occurred, and the orientation has not changed, no data need be transmitted, thus saving battery life. If no events occur over a prolonged period of time, say twenty seconds, the sensor can be placed in a power down mode. When held in either hand, even if not being used, the sensor will sense small changes in orientation, indicating that it is probably about to be used. If data is available for transmission, control is directed to step **907**, where data is transferred over a serial link from the DSP **403** to the radio transmitter **404**, for transmission to the computer **101**.

The step of identifying the drag position **903**, shown in *Figure 9*, is detailed in *Figure 10*. At step **1001** the four channels of buffered audio data are analysed to identify the three with the greatest amplitude. These three are the channels whose analysis will yield the most accurate touch event characterisation. The three loudest channels are called A, B and C. At step **1002** the first of these three channels is selected. At step **1003** a frequency

domain analysis is performed, and the results of this are normalised, such that the loudest frequency component has an amplitude of one. At step **1003** a correlation is performed with respect to a set of templates. Each template characterises a particular frequency response that is expected to occur at a known distance from a microphone. Thus, with reference to *Figure 7*, a template exists for the frequency characteristic at **701**, **702**, **703** and **704**. Each template has a different shape. The degree to which actual microphone data matches one of these templates indicates its proximity to the characteristic distance of that template.

A correlation score is generated as a result of step **1004**, and at step **1005** the two best scoring templates are selected. It is then known that the actual distance of the event from the microphone for that channel is between the characteristic distances of these two templates. At step **1006** the actual distance is identified by interpolating between the two characteristic distances, in proportion to the difference between the template scores. This identifies the characteristic distance for the channel, which may be DA, DB or DC, depending on which channel is being analysed. At step **1007** a question is asked as to whether there is another channel remaining to be analysed. If so, control is directed back to step **1002**. Alternatively, each distance DA, DB and DC will have been identified. At step **1008** intersecting arcs are identified across the surface of the sphere for each characteristic distance, and at step **1009** a point, P, is identified that is defined by the nearest point of convergence for the three arcs defined by DA, DB and DC.

The templates that are used in step **1004** in *Figure 10* are illustrated in *Figure 11*. Template **1101** corresponds to an ideal frequency response at a distance of D=40 mm away from a microphone. The signal at **701** in

Figure 7 would closely match this template. Template **1102** has a characteristic distance D=25 mm. and roughly corresponds to the plot at position **702** in *Figure 7*. Template **1103** has a characteristic distance D=10 mm, and would provide a high score for a signal occurring just after point **703** in *Figure 7*. Template **1104** corresponds to the fingertip being directly over the microphone, and corresponds to point **704** in *Figure 7*. By selecting the best two corresponding templates, the actual distance of the event from the microphone may be identified by interpolation between characteristic distances of the templates.

The distance of an event may be considered as a notional distance, as frequency characteristics may change for different finger sizes, applied pressure and other variable factors. Whatever the distances are, DA, DB and DC define three characteristic arcs, whose ideal convergence point P is illustrated in *Figure 12*. The ideal convergence point is the same regardless of these variable factors.

Identification of a hit position, shown at step **904** in *Figure 9*, is detailed in *Figure 13*. At step **1301** the three loudest channels A, B and C are identified. At step **1302** the first of these channels is selected for analysis. At step **1303** the signal is filtered. The filter removes frequencies below two hundred and fifty Hz, as this results in a better analysis being performed. Preferably an FIR linear phase filter is used. However, an IIR filter, such as that used to generate the trace shown in *Figure 8*, is acceptable, with a slightly reduced accuracy of results. At step **1304** an event start time is identified by analysing the channel data. At step **1305** a question is asked as to whether another channel remains to be analysed, and if so, control is directed back to step **1302**. Alternatively, start times will have been identified for each of channels A, B and C, and control is

directed to step **1306**.

The difference between start times for a pair of channels identifies a distance from the mid point between two microphones. On the surface of the sphere, this mid point is expressed as a line. At step **1306** distances are identified for each combination of start times, resulting in three lines, or arcs, being identified across the surface of the sphere. At step **1307** a characteristic common point is identified, in a similar manner to that shown in *Figure 12*. In theory, two such arcs are required. However, three are used to improve accuracy. Four may be used, if the channel data for all four microphones is of sufficiently high quality.

The invention provides a method of generating positional information by analysing the noise generated by friction between an object and a surface. Preferably the friction is generated by the movement of a finger across a surface. The surface may be flat, or curved, regularly or irregularly, or spherical. The surface may be elastic, temporarily or permanently deformable under finger pressure, or rigid. The invention includes any kind of interaction between a user's fingers and any such surface where resulting sounds are analysed to generate position information for a computer-generated environment. Position information generated in this way may be combined with information that defines the orientation of the surface with the projection upon a display device of a computer generated environment. This combination of position and orientation information enables sound-generating touch events made upon the surface to be interpreted with respect to a computer environment, irrespective of the orientation of the surface.

Orientation of the sensor is defined by rotations RM and RG about Earth's magnetic and gravitational fields. Detail of the orientation sensors

405 shown in *Figure 4* is shown in *Figure 14*. A magnetic field sensor **1401** and a gravity field sensor **1402** generate digital oscillation signals whose periods are measured in order to ascertain orientations within respective fields. A multiplexer and counter circuit **1403** provides interfacing and control signals for the oscillating circuits, and divides the frequencies down by an amount suitable for highly accurate measurement by the timers **502** in the DSP **403**.

The magnetic field sensor **1401** is detailed in *Figures 15* and *16*. *Figure 15* shows three mutually orthogonal inductors. Each inductor is less than ten millimetres long. *Figure 16* details a circuit suitable for detecting the polarity and magnitude of the Earth's magnetic field with respect to each of the three inductors. A logic gate **1601** provides a positive or negative DC bias via resistor **1602** to the presently selected inductor **1501** to **1503**. Selection of an inductor is provided by logical control signals supplied to tri-state logic buffers **1602**, **1603** and **1604**. An operational amplifier **1605** provides amplification for sustaining oscillations whose frequency is determined by the inductance of the selected inductor **1501** to **1503**. The DC bias provided by resistor **1602** drives the core of the selected inductor to near saturation.

Near to saturation, a coil's inductance changes in response to the applied field, even though the coil's windings and core are fixed. The additional offset towards or away from saturation, resulting from the Earth's magnetic field, may be detected in this way. By switching polarity of the DC bias in the coil, it is possible to determine the polarity of the Earth's magnetic field when different resulting oscillation frequencies are compared. If there is no difference, this indicates that the coil is aligned orthogonally to the Earth's magnetic field. The output from the operational

amplifier **1605** is supplied as a logic signal to the counter **1403**, and the DSP **403** determines the precise frequency of oscillation for each of the coils, in each polarity, and thereby the alignment, in three dimensions, of magnetic North. The circuit requires a couple of milliamps of current to operate, and the sensors are extremely small and of low cost. A suitable inductor, of the type shown in *Figure 15*, is the SEN-M magneto-inductive sensor, available from Precision Navigation of Menlo Park, California. Use of partly saturating inductors to detect the Earth's magnetic field in this way is detailed in United States patent 4,851,775.

The gravity field sensor **1402**, shown in *Figure 14*, is detailed in *Figures 17* and *18*. An enclosed spherical container is half filled with a liquid having a substantially different relative permeability to that of free space, at a frequency of around five hundred kHz. A suitable liquid is mercury, which has a relative permeability of around 0.7 at this frequency. Three coils **1702**, **1703** and **1704** are wound in close proximity to the container **1701**, and are mutually orthogonal. Each coil is connected in an oscillator circuit as shown in *Figure 18*. Each coil forms the inductive part of a tuned circuit, that also comprises two capacitors. A logical HCMOS NOR gate **1801** to **1803** provides amplification and a selection input to activate the oscillator circuits separately. The outputs from the oscillators are combined in a three-input NOR gate **1804**, so that an inductor selected for oscillation by a logical high input to gate **1801**, **1802** or **1803**, has its characteristic frequency presented as a square wave at the output of gate **1804**. The output from gate **1804** is supplied to the counter circuit **1403**. The frequencies of oscillation of the three coils depend upon the amount of immediately adjacent mercury. The three frequencies are measured in the DSP 403, and interpolated look-up tables are used to determine the actual

orientation of the sensor with respect to the Earth's gravitational field. The circuit of *Figure 18* requires less than one milliamp to operate.

The three-dimensional vectors for magnetic and gravitational ambient fields may be represented as two rotations of the sphere, RM and RG, about the magnetic North axis, and about the vertical gravitational axis.

The process of identifying RM and RG combines measurements from both the gravitational and magnetic field sensors. It is possible for either to experience interference, and the gravitational field sensor **1402** may experience instability due to motion of the mercury in the container **1701**, particularly if the sensor is moved about rapidly. The step of identifying the orientation of the sphere **905**, shown in *Figure 9*, is detailed in *Figure 19*. At step **1901** the rotation about magnetic North, RM, is identified. At step **1902** Kalman filtering is applied to the value of RM. A Kalman filter determines a measure of confidence in the current measurement, and increases low pass filtering when this confidence value is low. At step **1903** the rotation RG of the sphere about the vertical axis due to gravity is determined, and at step 1904 Kalman filtering is also applied to this value. At step **1905**, filtered values for RM and RG are stored for later transmission to the computer **101** when necessary.

In an alternative embodiment the Earth's magnetic field can be detected using silicon sensors employing the giant magneto-resistive effect. In a further alternative embodiment the Earth's gravitational field can be detected using accelerometers, which are more expensive, but facilitate detection of rapid acceleration of the ball **104**, which may be used as a further source of gestural information for navigating a computer environment.

After an extended period of use, the battery **407** requires recharging.

In order to recharge, the inductive loop **305** must be placed in an adjacent position to another matching inductive loop that is supplied by a 1kHz power source. This may be located in a charging unit as illustrated in *Figure 20*. The outside of the sphere has a mark directly opposite the location of the inductive loop **305**, and this mark must be uppermost when the sphere is placed on the recharging unit **2001**. The recharger **2001** may also conveniently double as the receiver for the data from the transmitter circuit **404**, and a serial connection **2002** provides the connection for this data to the computer terminal **101**.

Details of the charger and receiver unit **2001** are shown in *Figure 21*. An inductive loop and oscillator **2101** supply an alternating magnetic field to the inductive loop **305** in the sensor **104** during recharging. During use, the sensor **104** transmits radio signals to a radio receiver **2102**. A central processing unit (CPU) **2103** provides error correction of data received over the radio link. A universal serial bus (USB) interface **2104** provides a connection to the computer terminal **101** via the serial cable **2002**.

The computer terminal **101** shown in *Figure 1* is detailed in *Figure 2*. A central processing unit (CPU) **2203** provides co-ordination and processing for the terminal **101**. Instructions and data for the CPU **2203** are stored in main memory **2204**, and a hard disk storage unit **2205** facilitates non-volatile storage of data and several software applications. A modem **2206** provides a connection to the internet. A universal serial bus (USB) interface **2207** facilitates connection to the charger and receiver unit **2001**. Touch event and orientation data are received from the sphere **104** via the USB interface **2207**. A graphical processor **2208** provides dedicated graphics rendering capabilities to speed up the display of high resolution graphical images on the display **102**. An audio processor **2209** supplies

audio signals to loudspeakers in the computer terminal **101**, and receives audio signals from a microphone **2211**.

The contents of the main memory **2204** shown in *Figure 22* are detailed in *Figure 23*. An operating system provides common functionality for software applications **2302**. A device driver **2303** for the sensor **104** is also stored in main memory **2204** while the computer terminal **101** is switched on. The sequence of operations necessary to operate the sensor **104** is detailed in *Figure 24*. At step **2401** the sensor **104** is charged using the charger and receiver unit **2001** shown in *Figures 20* and *21*. At step **2402** the sensor is calibrated. In order to use the sensor, it is necessary to store orientation data so that the device driver **2303** is able to determine which way is forward, backwards, left and right with respect to the Earth's magnetic field, and therefore also substantially with respect to the terminal **101**.

It is assumed herein that orientation of the sensor within the Earth's magnetic and gravitational fields effectively provides orientation with respect to the terminal **101**. Clearly this would be untrue if the user operated the sensor from behind the terminal. However, for the purposes of practically operating the sensor, it may be assumed that touch gestures on the surface of the sphere **104** that are made with respect to the Earth's magnetic and gravitational fields are also made with respect to the location of the computer terminal **101**. If the terminal position is changed substantially, it will be necessary to perform the calibration at step **2402** again. At step **2403** the sensor **104** is used, and at step **2404** the sensor **104** is recharged. The design of the charger and receiver unit **2001** is such that the sensor **104** may be conveniently left at rest on the charger **2001** whenever it is not in use.

The step of calibrating the sensor **2402**, shown in *Figure 24*, is detailed in *Figure 25*. At step **2501** the computer requests the user to drag their finger from the back to the front of the sensor, moving over the middle of the top. After this is done, the computer requests the user to drag from left to right in the same fashion. Although both are not strictly necessary, this reduces the error in calibration. At step **2502** the orientation data from the sphere **104** is analysed in order to determine a user orientation angle AG, about the vertical axis of the Earth's gravitational field.

The step of using the sensor **2403**, shown in *Figure 24*, is detailed in *Figure 26*. At step **2601** touch event and or orientation data is received from the sensor **104**. This includes the angles of rotation RM and RG about the Earth's magnetic and gravitational fields. At step **2602** the user orientation angle AG calculated at step **2502** in *Figure 25* is subtracted from the sphere rotation angle RG in order to obtain a rotation value SG. At step **2603** a question is asked as to whether a touch event has been received. If not, control is directed to step **2606**. Alternatively, control is directed to step **2604**. At step **2604** the sphere co-ordinates of the touch event are rotated in opposite and equal degree to SG and RM, resulting in touch event data that has a stationary co-ordinate system, irrespective of the orientation of the sphere. At step **2605** the resulting touch event data is processed. Finally, at step **2606** the terminal-oriented data is supplied to the operating system **2301** via the device driver **2303**, for use by applications **2302**.

The step of processing touch event data **2605**, shown in *Figure 26*, is detailed in *Figure 27*. At step **2701** a question is asked as to whether a large hit has been received. A large hit is one where audio data from all four microphone channels is extremely loud, indicating the user has hit the sensor quite hard, request a change of mode. If a large hit is received,

control is directed to step **2702** where the current mode is swapped. Alternatively, if a large hit is not identified at step **2701**, control is directed to step **2703**. At step **2703** a question is asked as to whether the currently selected mode for the sensor is graphics mode or text mode. If text mode is selected, control is directed to step **2706**. Alternatively, graphics mode is identified, and control is directed to step **2704**. At step **2704** any small hits are interpreted as the equivalent of mouse button clicks. Finger drag events are used to modify the X and Y co-ordinates of the cursor. At step **2705** the cursor position is updated.

When used in text mode, control is directed from step **2703** to step **2706**. At step **2706** any small hits are interpreted as the equivalent of CAPS, CTRL and SHIFT events on a conventional keyboard. At step **2707** touch movements on the surface of the sphere are interpreted as character entry events. Alternatively, for high speed text entry, a form of shorthand can be used.

In an alternative embodiment, the DSP **403** performs data compression of audio signals from the microphones **201** to **204**. The compressed audio data is combined with orientation data, and is transmitted to the computer terminal **101** for analysis to determine surface event characteristics.

In the embodiments described above, the sensor is a passive device, requiring a sound to be made by a touch event on the surface of the sphere. In an alternative embodiment, an active sensor is provided. Sound may be injected into the surface of the sphere, and a surface pressure map may be constructed from sound characteristics that result from interference and reflection. If the sensor shell is made of a hard material, ultrasonic sound may be used to generate a highly detailed pressure map. The

pressure data may be used to facilitate additional methods of data entry. An alternative method of detecting pressure is the use of multiplexed pressure sensitive electrical sensors, whose conductivity changes in accordance with the applied pressure.

In a further alternative embodiment, touch events are detected by an electrical sensor in which capacitance of electrical conductors, near or embedded in the sphere's surface, is modified by the presence of parts of a hand or finger.

The spherical shape of the sensor facilitates rotation in any degree without this making any difference to the appearance or feel presented to the user. Touch events on the surface are made with respect to the computer display **102**. This has the psychological effect of extending the computer generated environment out into the space between the user and the terminal.

Although in the preferred embodiment the entire surface of the sphere is touch sensitive, it is possible that, for the purpose of providing a direct electrical connection during recharging, that a different embodiment may include an insignificant portion of its surface where touch sensing is not fully provided. Also, in certain embodiments, the spherical shape may be distorted, as a result of squeezing or due to a preferred distorted shape.

The sphere, being the simplest of three dimensional shapes, provides a suitable shape for universal object mapping. A complex shape, such as a telephone handset, may have its surface mapped to the surface of the spherical sensor **104**, and interaction with the handset, for example to dial a number, may be effected via interactions with the sphere. Alternatively, the shape of a three-dimensional object mapped in such a way may be modified using the touch events on the sensor's surface. The

shape, then changed, is remapped to the surface of the sphere, so that additional changes may be made. The universal shape of the sphere lends itself to interaction with a rich variety of complex shapes and forms.

Claims

1. Input apparatus for a data processing system having the form of a fully enclosed substantially spherical object, including touch-sensing means for generating position signals indicative of the position of touched events occurring anywhere on the surface of the object;

orientation sensing means for identifying the orientation of the object;

processing means for combining touch data with orientation data; and

transmitting means arranged to transmit processed data to a data processing system.

2. Apparatus according to claim 1, wherein said processed data represents said touch event signals orientated with respect to said display apparatus, by making reference to said orientation signals.

3. Apparatus according to claim 2, wherein said orientation sensing means includes an ambient magnetic field sensor.

4. Apparatus according to claim 3, wherein said magnetic field sensor comprises three mutually orthogonal magnetic field detectors.

5. Apparatus according to claim 2, wherein said orientation sensing means includes gravitational sensing means.

6. Apparatus according to claim 5, wherein said gravitational sensing means comprises

a mobile inductor core in an enclosure, and

three mutually orthogonal inductors responsive to the position of said mobile core.

7. Apparatus according to claim **6**, wherein a said inductor is included in an oscillating circuit.

8. Apparatus according to claim **7**, including counting means for measuring a frequency generated by said oscillating circuit

9. Apparatus according to claim **6**, including

means for measuring an inductance of a said inductor,

processing means for processing said measurement, wherein

said processing means includes look-up means for identifying the orientation of said sphere with respect to gravity.

10. Apparatus according to claim **1**, wherein said sensing means comprises a plurality of sound transducer means.

11. Apparatus according to claim **10**, wherein said sphere has a surface that generates sound in response to a touch event.

12. Apparatus according to claim **11**, wherein said sound generating surface generates a noise-like sound in response to a dragging motion of a finger.

13. Apparatus according to claim **11**, wherein said sensing means

comprises a plurality of microphones.

14. Apparatus according to claim **13**, including processing means arranged to compare signals from said microphones in order to identify a characteristic of a touch event.

15. Apparatus according to claim **14**, wherein said characteristic is a position.

16. Input apparatus for a computer with a graphic display means, having the form of a fully enclosed sphere, including

touch sensing means for generating position signals indicative of the position of touch events occurring anywhere on said spherical surface,

transmitting means arranged to transmit signals to a computer in response to said position signals,

orientation detecting means for detecting orientation of said sphere, and

processing means configured to combine signals from said touch sensing means and said orientation detecting means for subsequent identification of a touch event orientation substantially with respect to said graphic display means.

17. Apparatus according to claim **16**, wherein said touch sensing means comprises a plurality of microphones and said sphere has a surface that generates sound in response to touch events.

18. Apparatus according to claim **17**, wherein said sphere has a

roughened surface.

19. Apparatus according to claim **16**, wherein said computer includes processing means configurable to perform steps of:

selecting a graphical or text mode for said sensor,

when in said graphical mode to perform steps for identifying a graphical instruction in response to touch events, and

when in said text mode to perform steps for identifying text in response to touch events.

20. Apparatus according to claim **16**, wherein said sensor includes rechargeable cell means and a recharging inductive loop means.

21. A method of generating control signals for a data processing systems displaying a graphical interface on a display apparatus, wherein

a sensor has a substantially spherical form and includes:

an outer surface and touch sensing means for generating position signals indicative of the position of touch events on said surface;

orientation sensing means for identifying orientation; and

transmitting means for transmitting sensed data to a data processing system, comprising steps of

identifying the position of a touch event on the surface of said sensor;

identifying the orientation of said sensor; and

combining data representation position with data representing said orientation to generate such event signals orientated substantially with respect to display apparatus.

22. A method according to claim **21**, wherein said touch sensing means includes acoustic transducer means, and said position signals are generated by processing sound signals.

23. A method according to claim **22**, wherein said sound processing includes frequency domain analysis.

24. A method according to claim **23**, including identifying probable distances from sensors of a touch event in response to frequency characteristics of sounds at said sensors.

25. A method according to claim **24**, wherein said distances are combined to identify a location.

26. A method according to claim **25**, wherein additional processing of said signals is performed in order to reduce positional error.

27. A method according to claim **23**, including measuring a time interval between the start of a sound at a plurality of acoustic transducer means.

28. A method according to claim **27**, wherein said sound is generated in response to a hit event on the surface of said sphere.

29. A method according to claim **23**, wherein frequency analysis is used to identify a characteristic of drag touch events and start-time

analysis is used to identify a characteristic of hit touch events.

30. A method of interacting with a three dimensional object model in a computer generated environment, wherein signals are supplied to said environment from a surface touch position sensitive sphere, comprising steps of:

generating a mapping from said sphere to said object; and

receiving touch events from said sphere and interpreting them to interact with a respective surface portion of said object.

31. A method of modifying a three dimensional object model in a computer generated environment, wherein signals are supplied to said environment from a surface touch position sensitive sphere, comprising steps of:

generating a mapping from said sphere to said object;

receiving touch events from said sphere and interpreting them to manipulate a respective surface portion of said object;

updating said object; and

generating a new mapping from said sphere to said object.

32. A method of generating positional input signals for a computer, in which the position of an interaction between a moving object and a surface is identified by an analysis of the sound generated by friction between said surface and said object.

33. A method according to claim **32**, wherein said object is a computer user's finger.

34. A method of supplying positional information to a computer, in which the position of an interaction between a user's finger and a surface generates sound by friction between said surface and said finger;

said sound is converted into an electrical signal by acoustic transducer means; and

signals derived from said sound are transmitted to a computer such that the position of said interaction controls a position characteristic in an environment generated by said computer.

35. Apparatus substantially as herein described with reference to *Figures 1*, *2*, *3* and *4*.

36. A method substantially as herein described with reference to *Figures 1*, *2*, *3* and *4*.

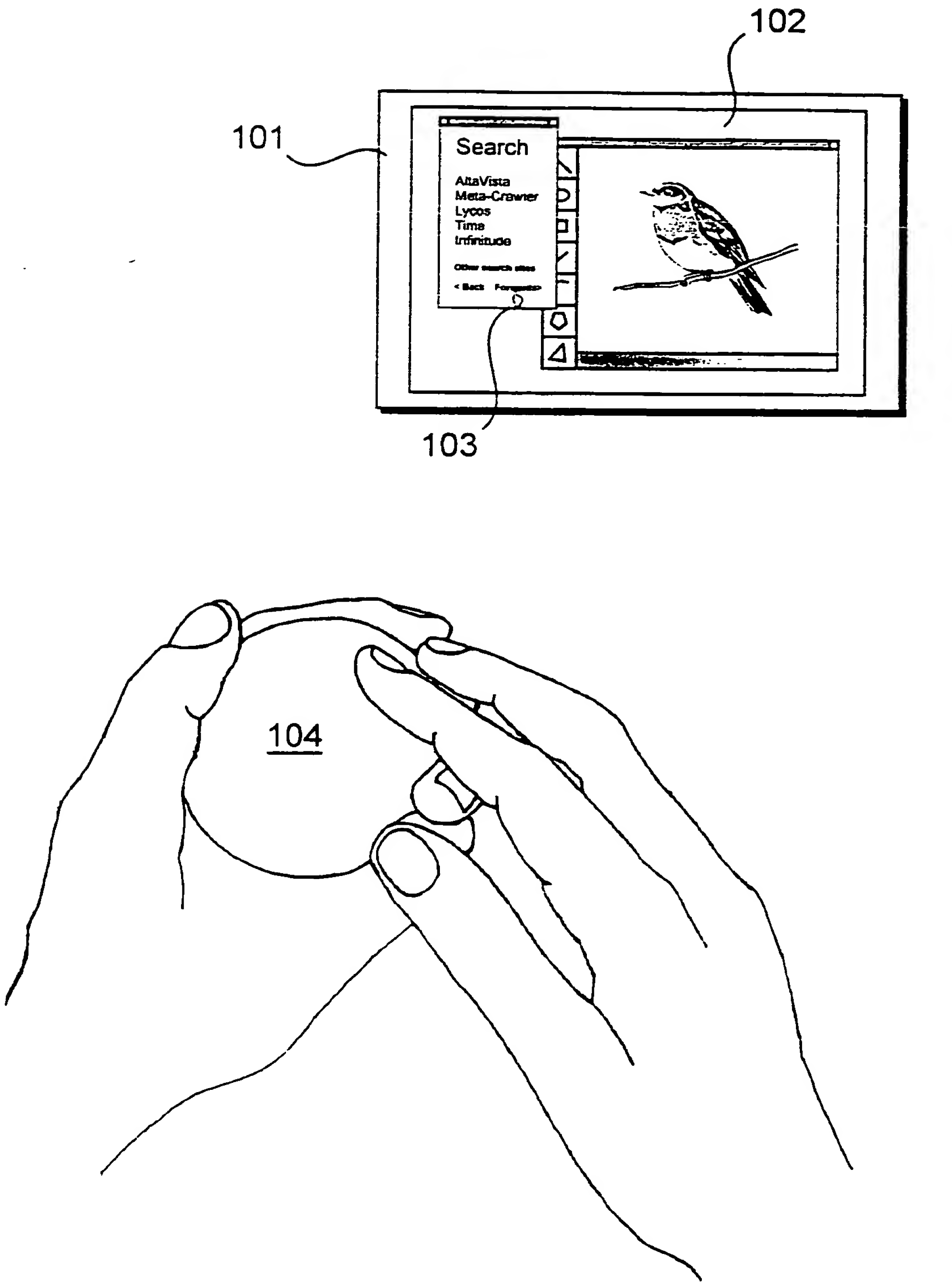

102
101
Search
AltaVista
Meta-Crawler
Lycos
Time
Infinitude
Other search sites
< Back
Forward>
103
104

Figure 1

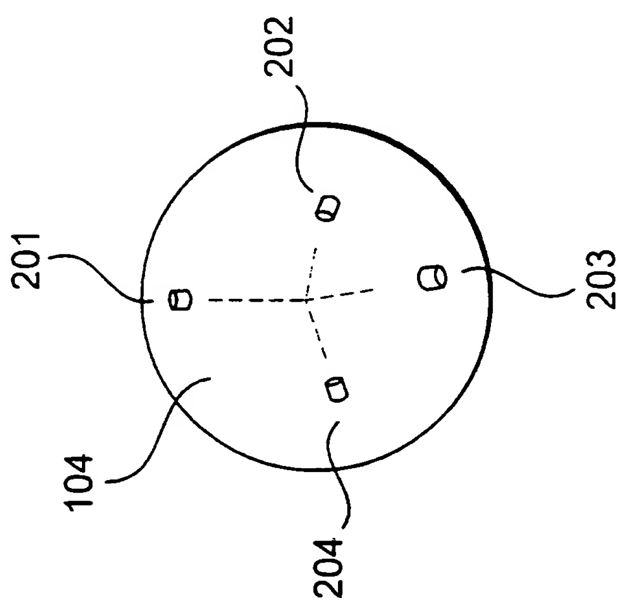


Figure 2

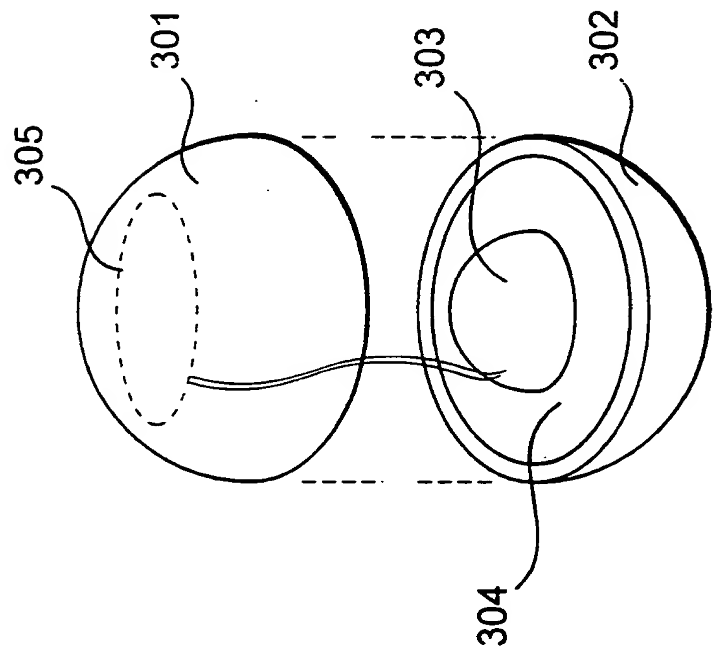


Figure 3

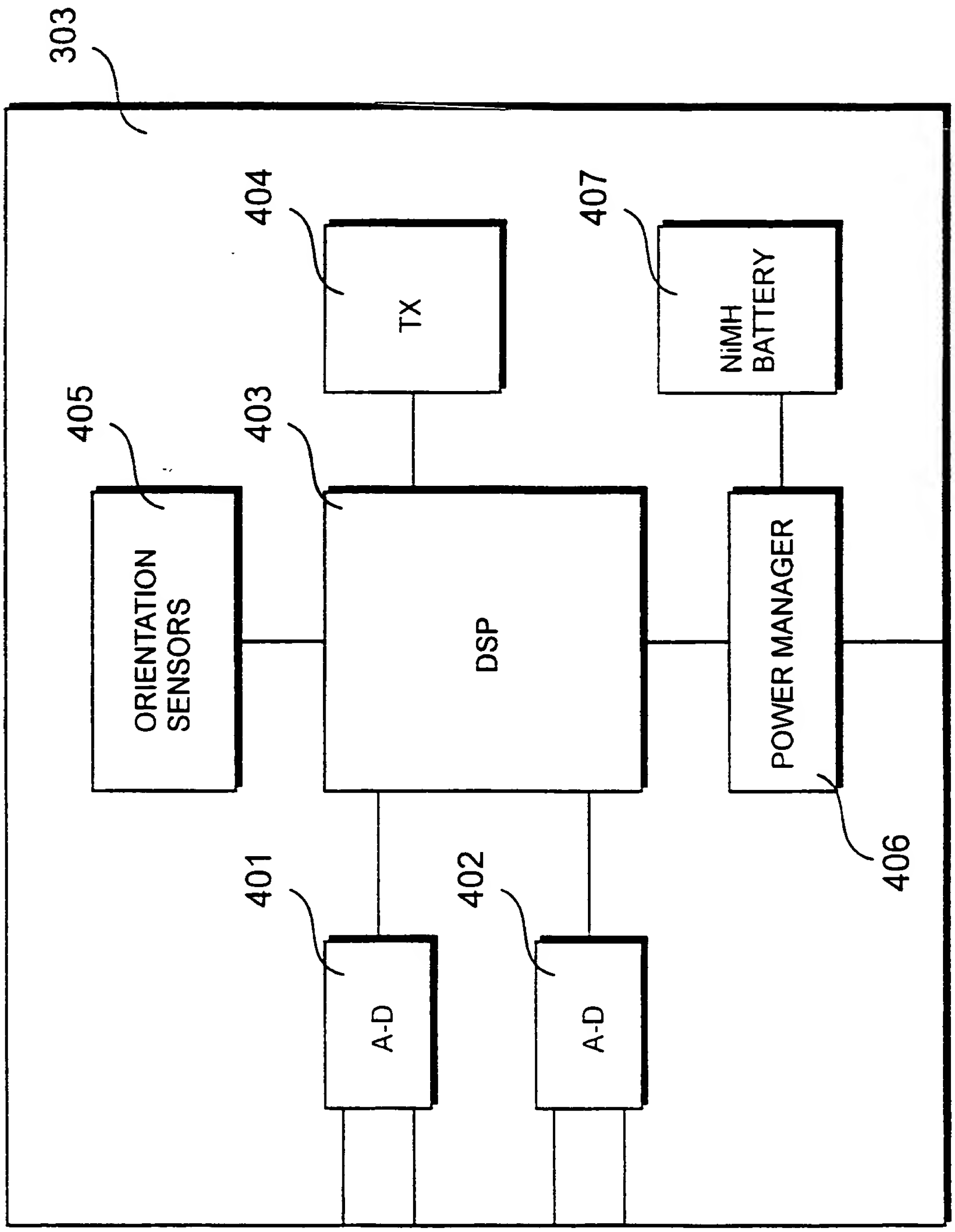

303
404
TX
407
NiMH BATTERY
405
ORIENTATION SENSORS
403
DSP
POWER MANAGER
406
401
A-D
402
A-D

Figure 4

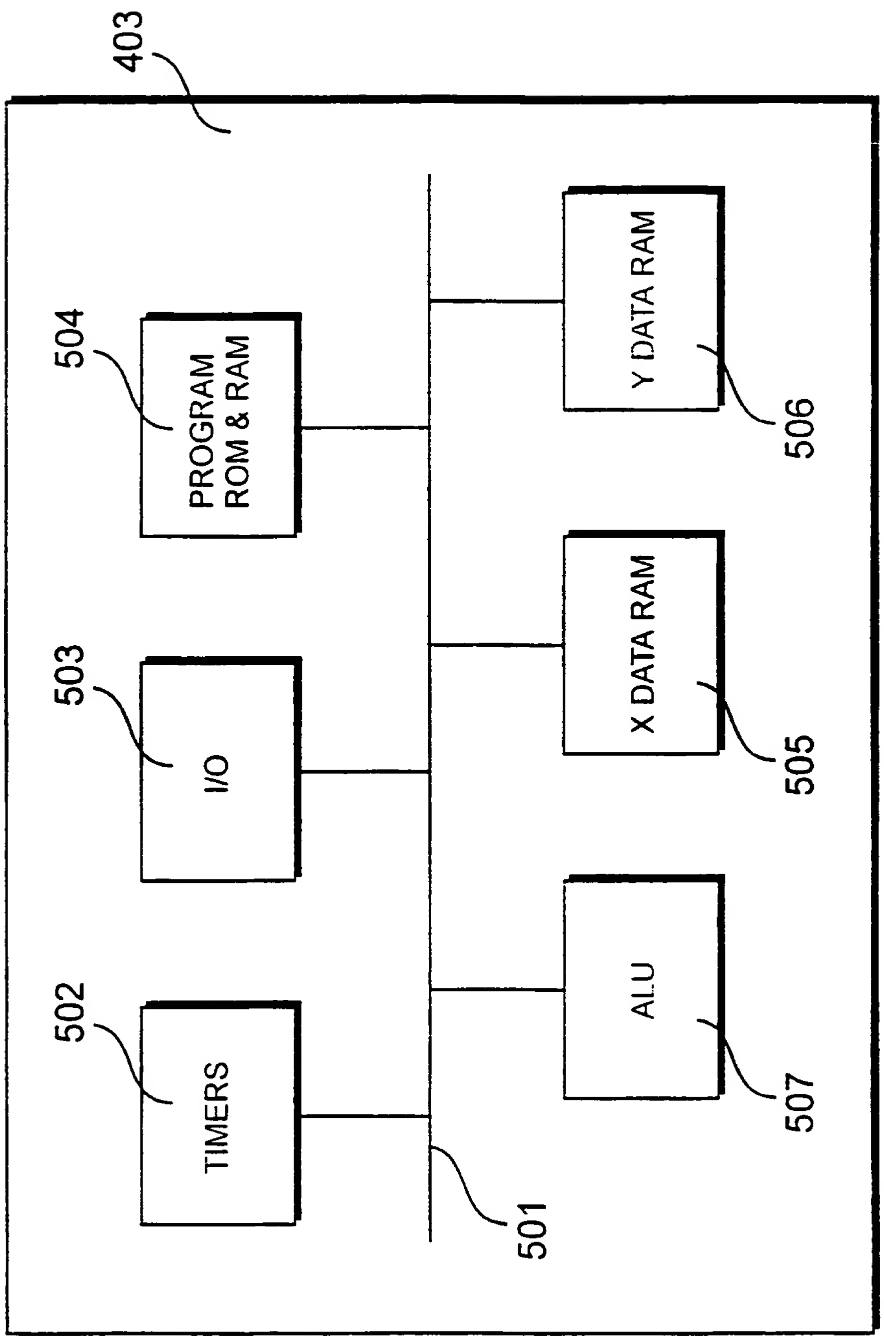

403
504
PROGRAM
ROM & RAM
503
I/O
502
TIMERS
501
Y DATA RAM
506
X DATA RAM
505
ALU
507

Figure 5

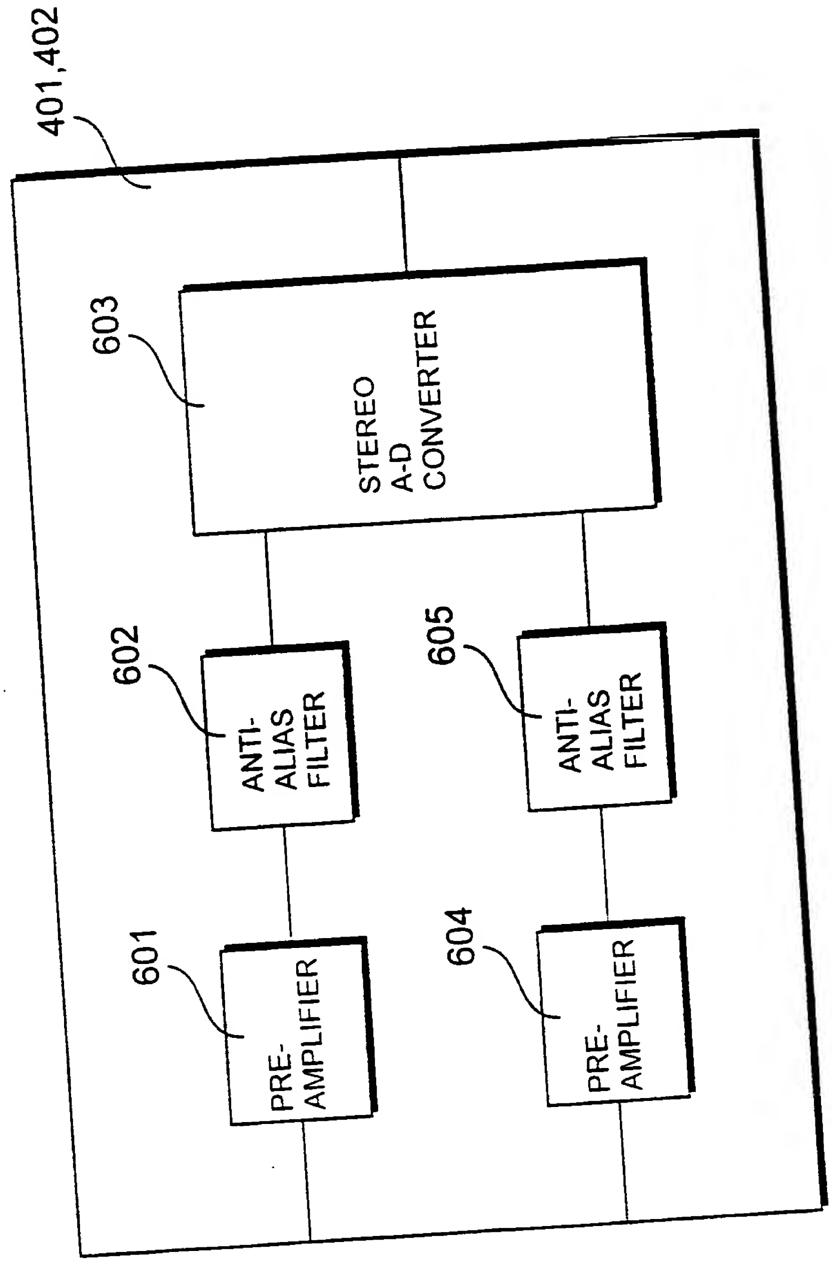

401,402
603
STEREO
A-D
CONVERTER
602
ANTI-
ALIAS
FILTER
605
ANTI-
ALIAS
FILTER
601
PRE-
AMPLIFIER
604
PRE-
AMPLIFIER

Figure 6

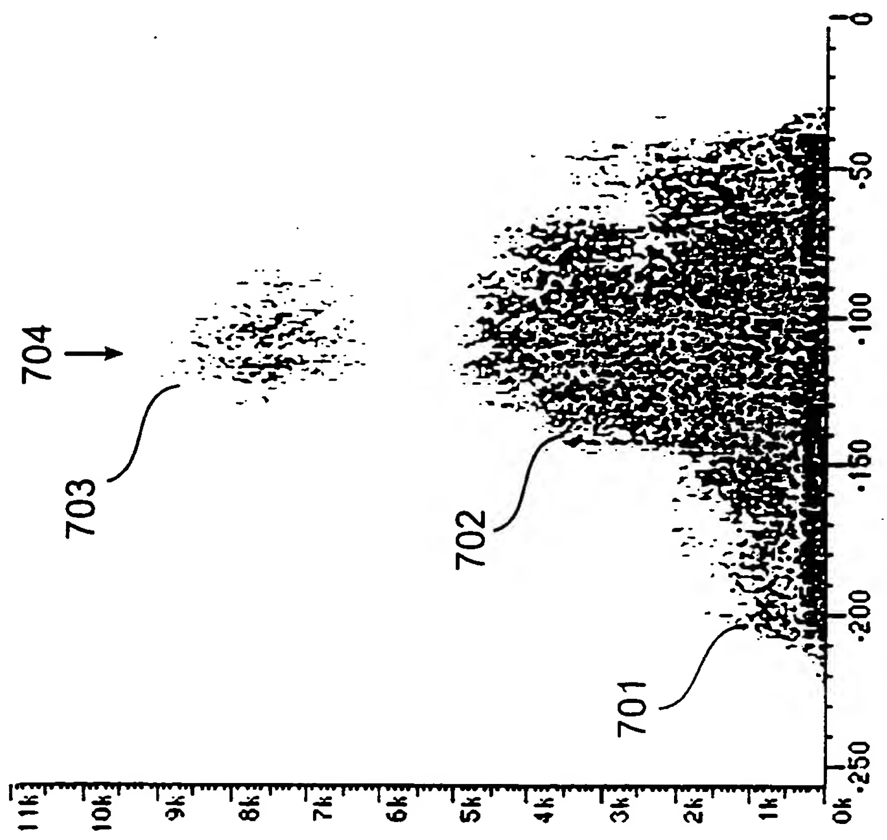

704
703
702
701
0k
1k
2k
3k
4k
5k
6k
7k
8k
9k
10k
11k
0
-50
-100
-150
-200
-250

Figure 7

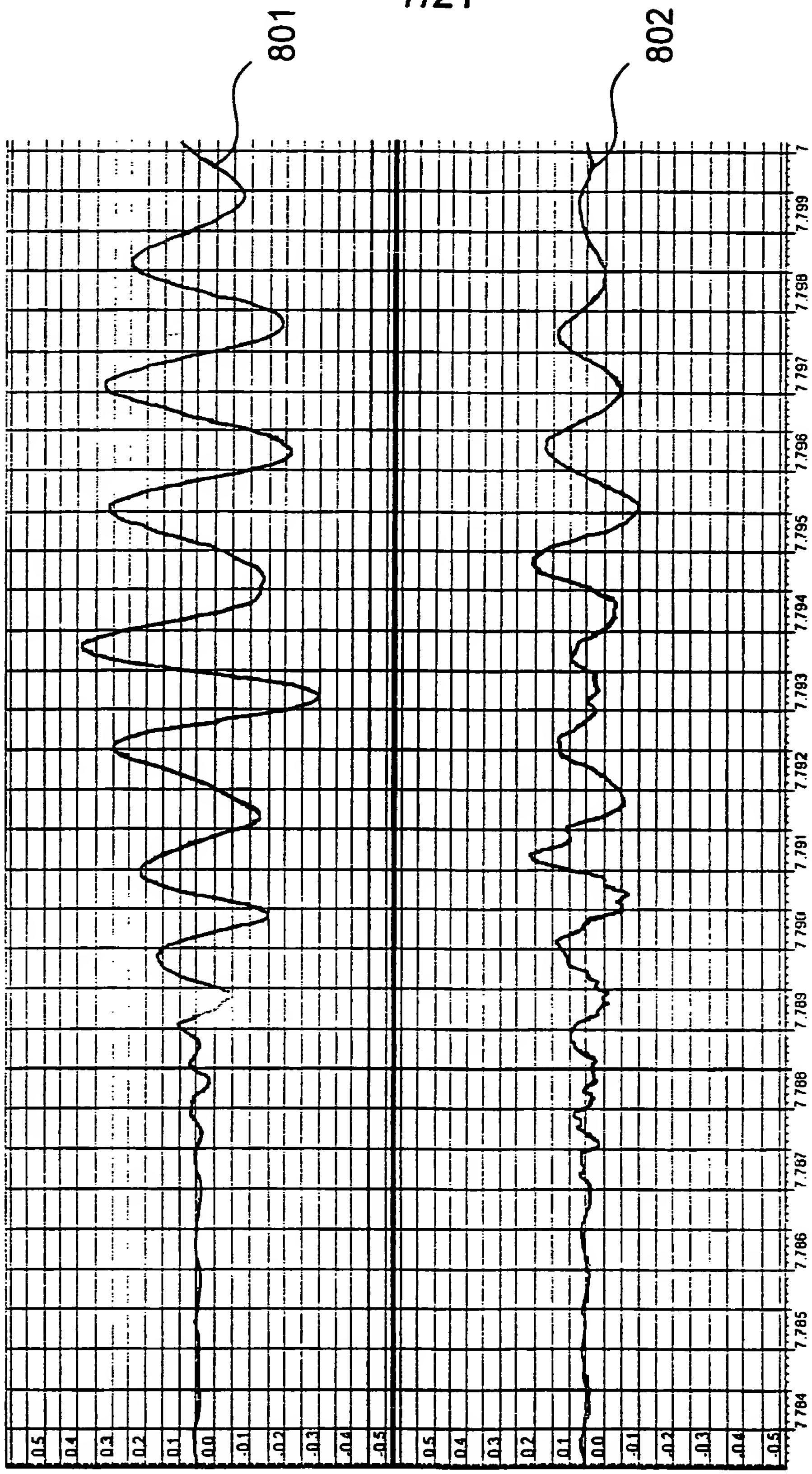


Figure 8

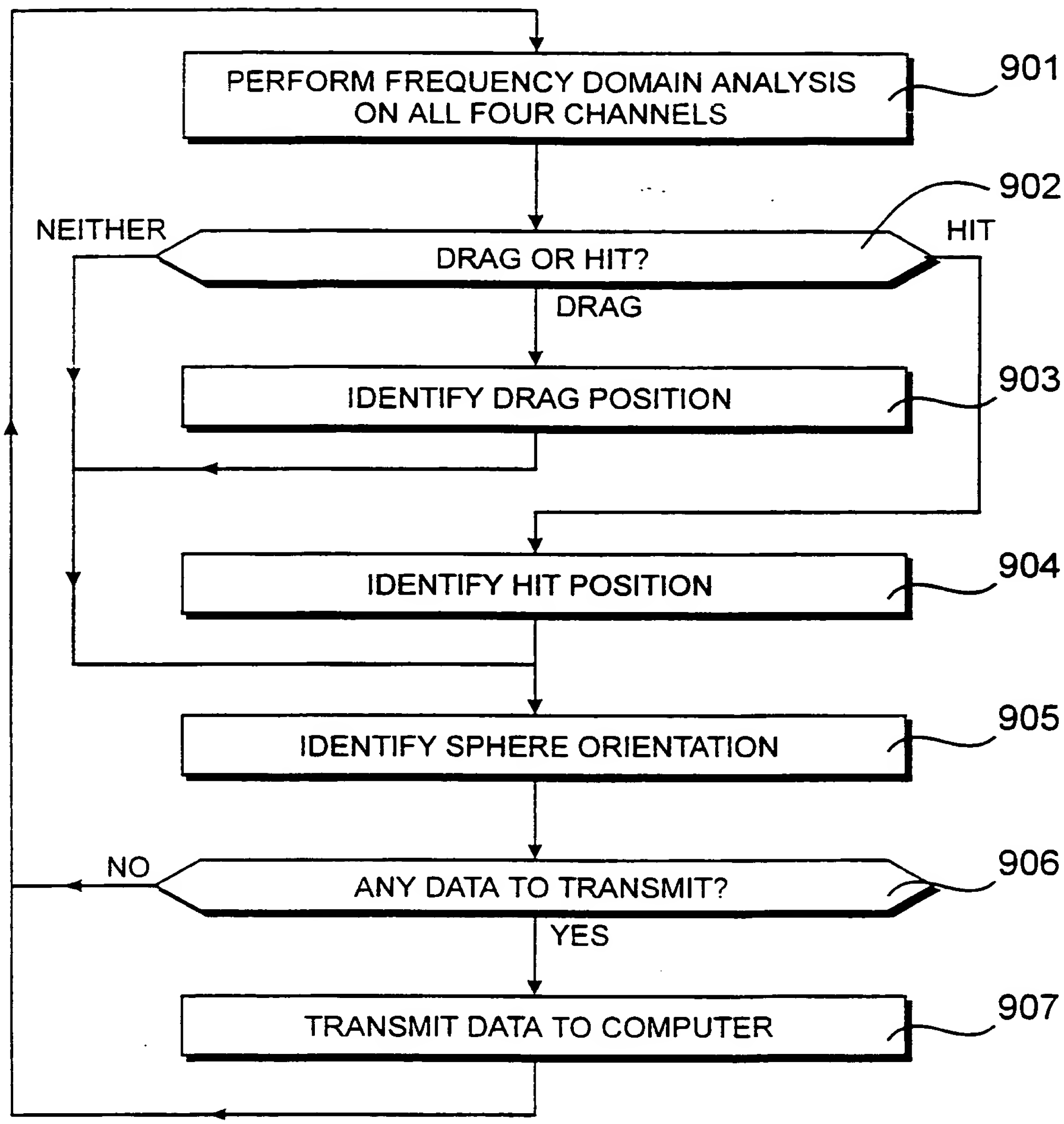

PERFORM FREQUENCY DOMAIN ANALYSIS ON ALL FOUR CHANNELS
901
DRAG OR HIT?
902
NEITHER
HIT
DRAG
IDENTIFY DRAG POSITION
903
IDENTIFY HIT POSITION
904
IDENTIFY SPHERE ORIENTATION
905
ANY DATA TO TRANSMIT?
906
NO
YES
TRANSMIT DATA TO COMPUTER
907

Figure 9

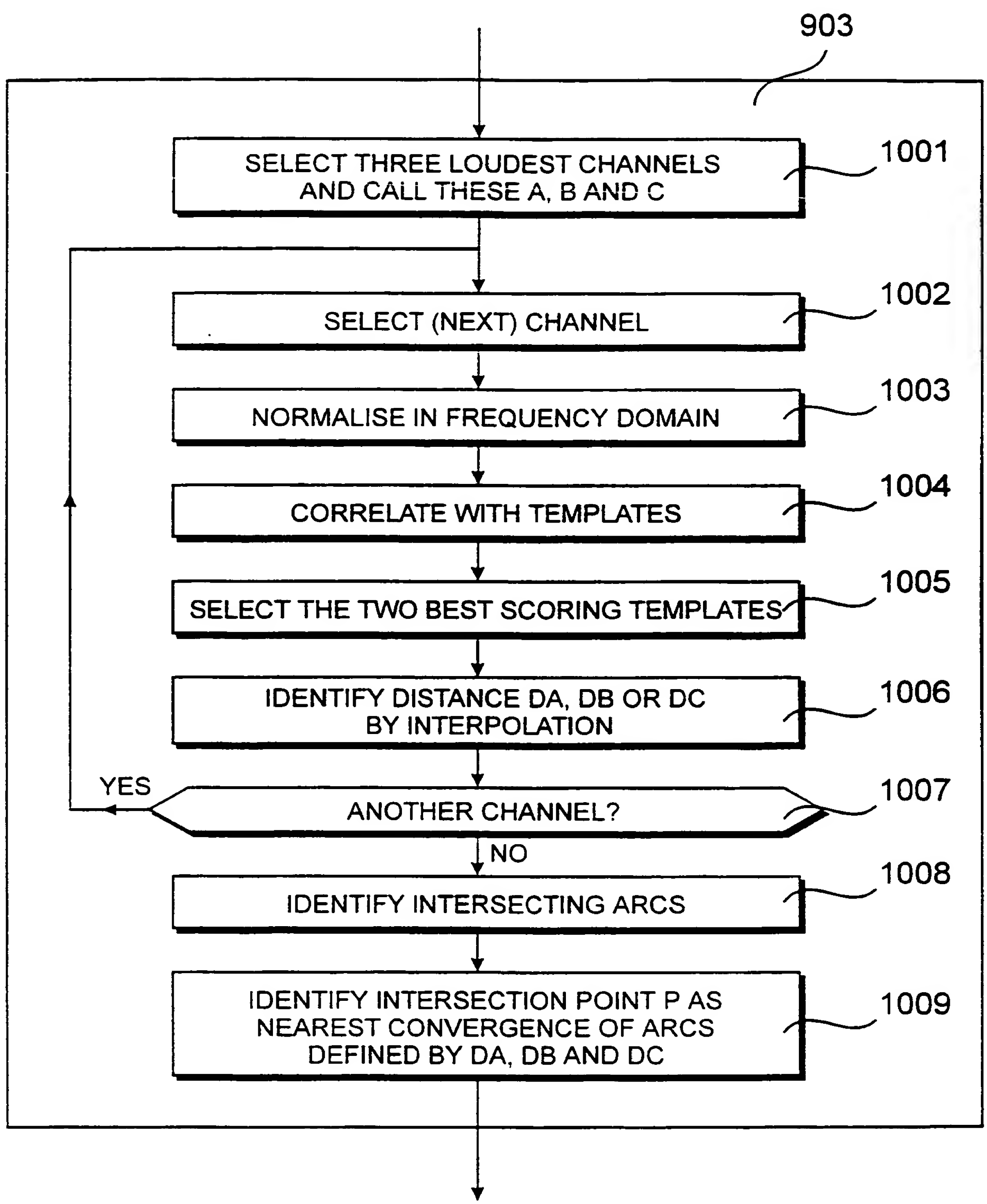

903
SELECT THREE LOUDEST CHANNELS AND CALL THESE A, B AND C
1001
SELECT (NEXT) CHANNEL
1002
NORMALISE IN FREQUENCY DOMAIN
1003
CORRELATE WITH TEMPLATES
1004
SELECT THE TWO BEST SCORING TEMPLATES
1005
IDENTIFY DISTANCE DA, DB OR DC BY INTERPOLATION
1006
YES
ANOTHER CHANNEL?
1007
NO
IDENTIFY INTERSECTING ARCS
1008
IDENTIFY INTERSECTION POINT P AS NEAREST CONVERGENCE OF ARCS DEFINED BY DA, DB AND DC
1009

Figure 10

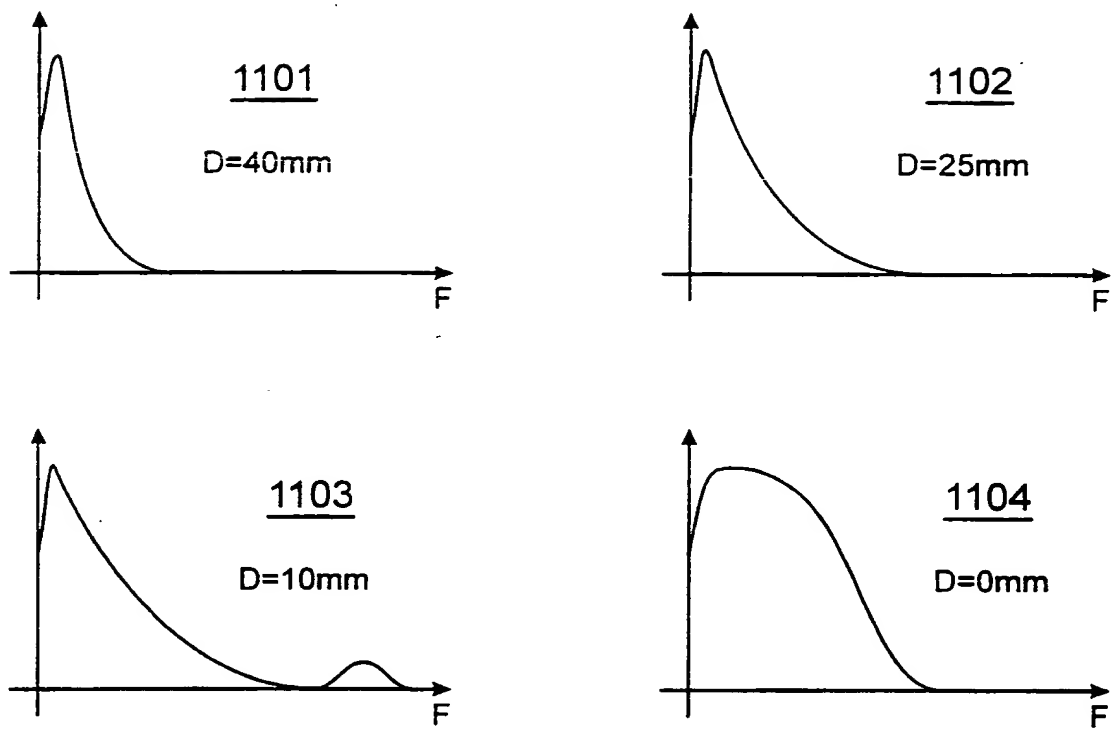


Figure 11

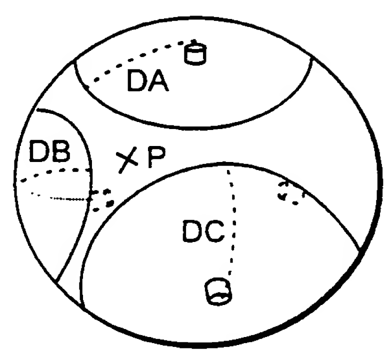


Figure 12

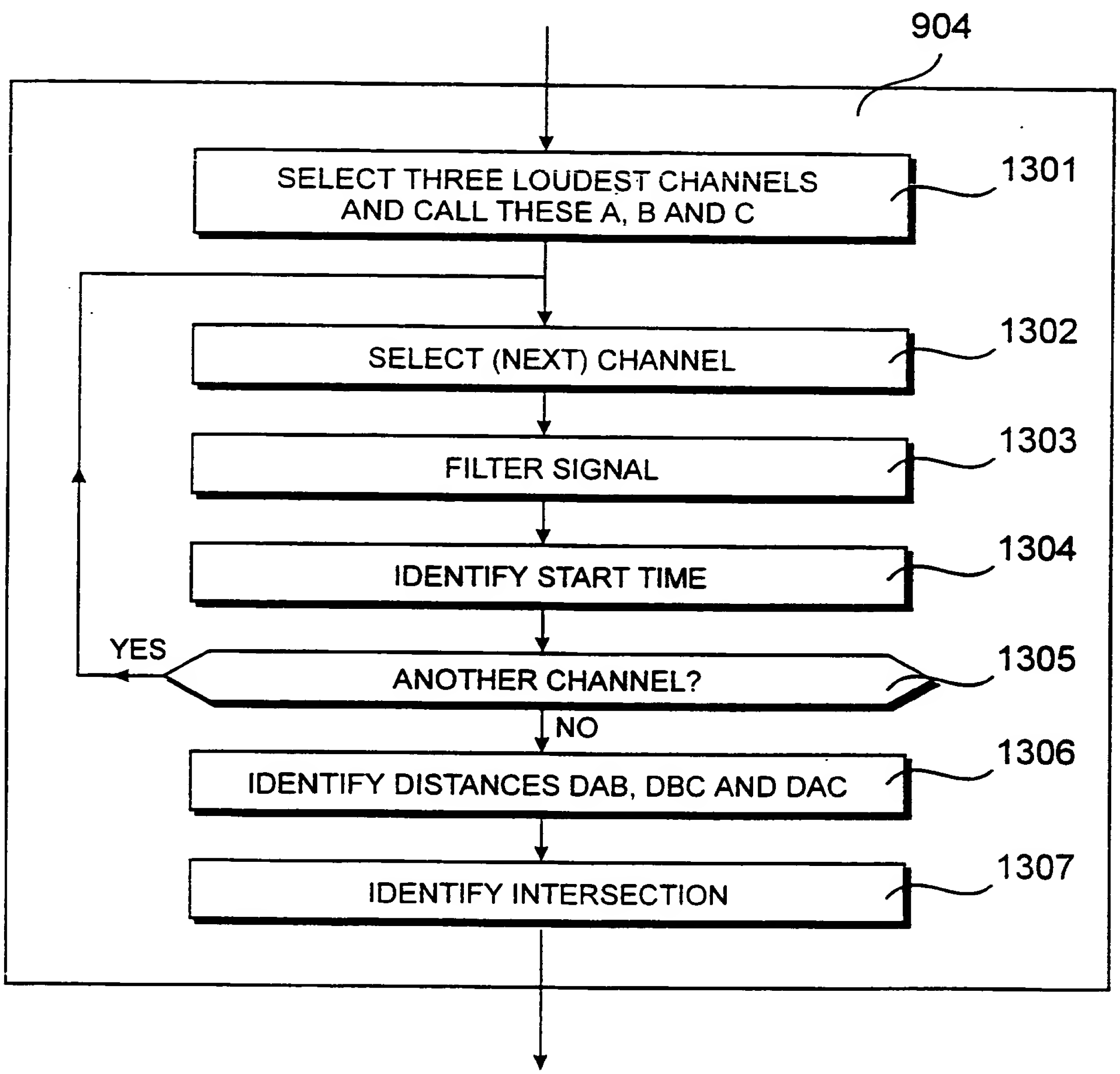

904
SELECT THREE LOUDEST CHANNELS AND CALL THESE A, B AND C
1301
SELECT (NEXT) CHANNEL
1302
FILTER SIGNAL
1303
IDENTIFY START TIME
1304
YES
ANOTHER CHANNEL?
1305
NO
IDENTIFY DISTANCES DAB, DBC AND DAC
1306
IDENTIFY INTERSECTION
1307

Figure 13

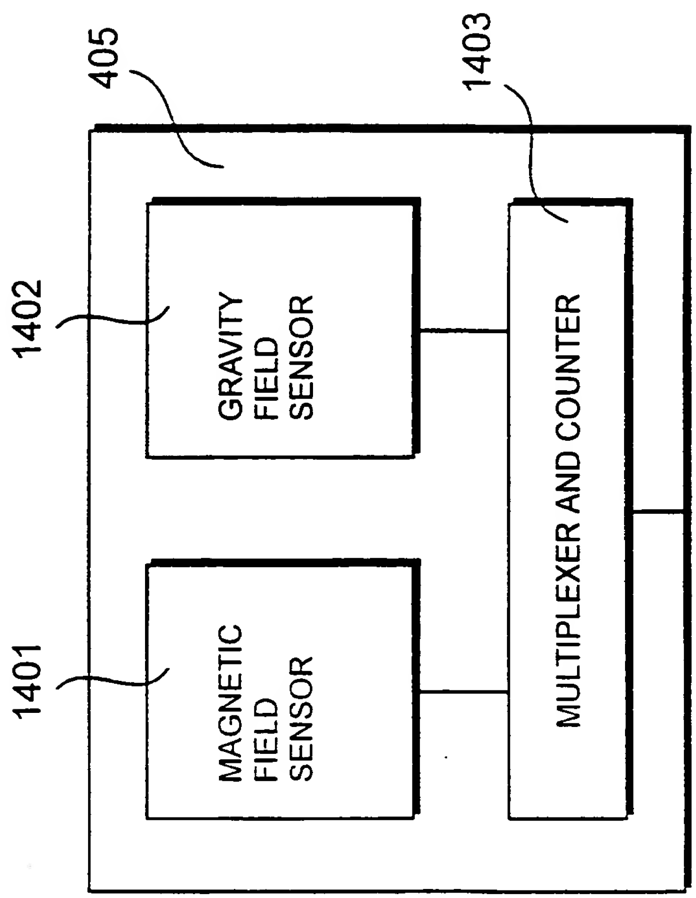

405
1403
1402
GRAVITY
FIELD
SENSOR
1401
MAGNETIC
FIELD
SENSOR
MULTIPLEXER AND COUNTER

Figure 14

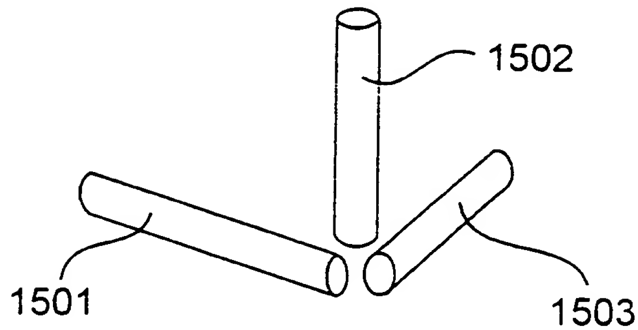


Figure 15

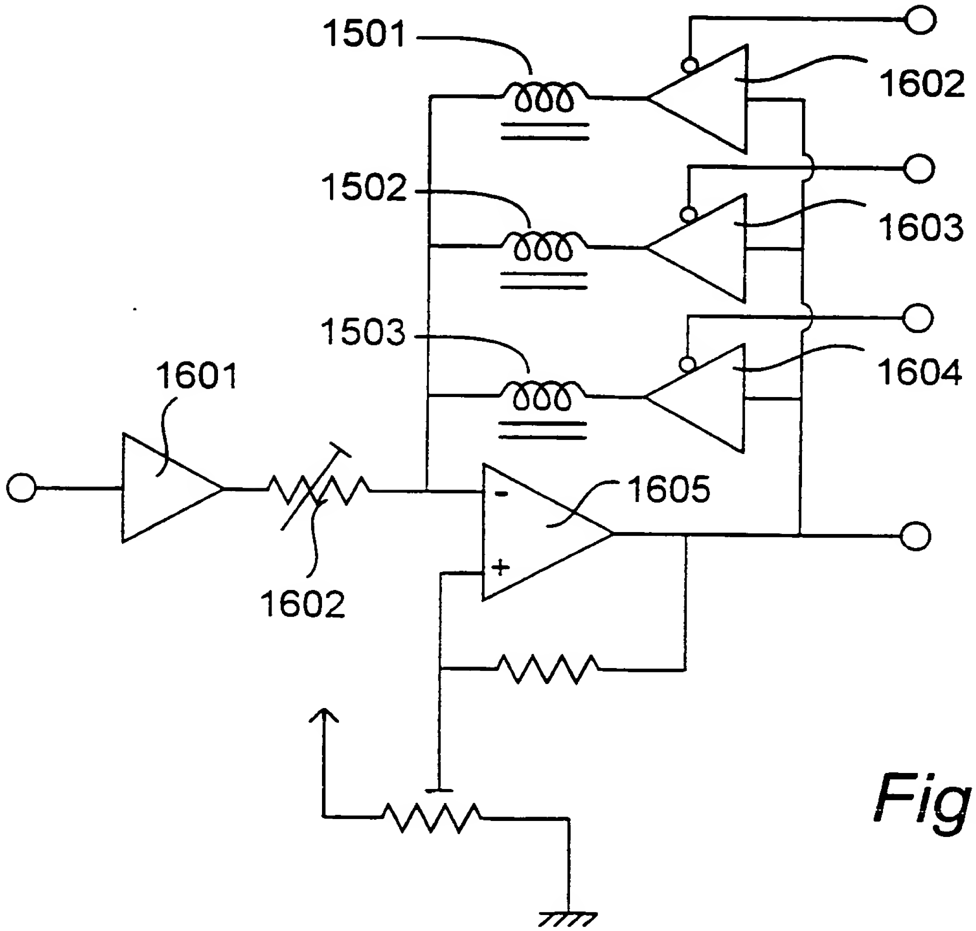


Figure 16

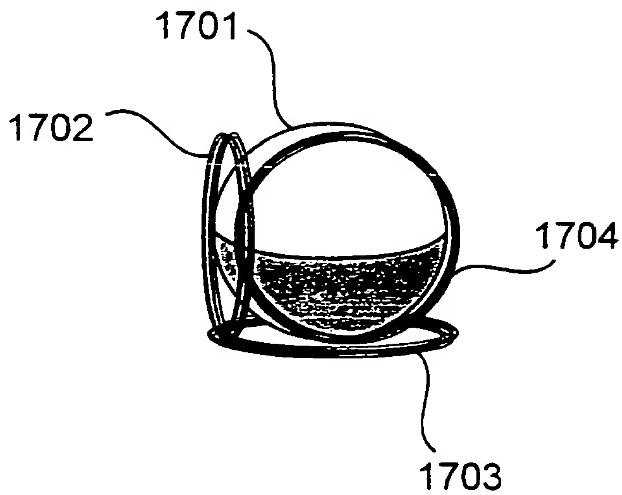


Figure 17

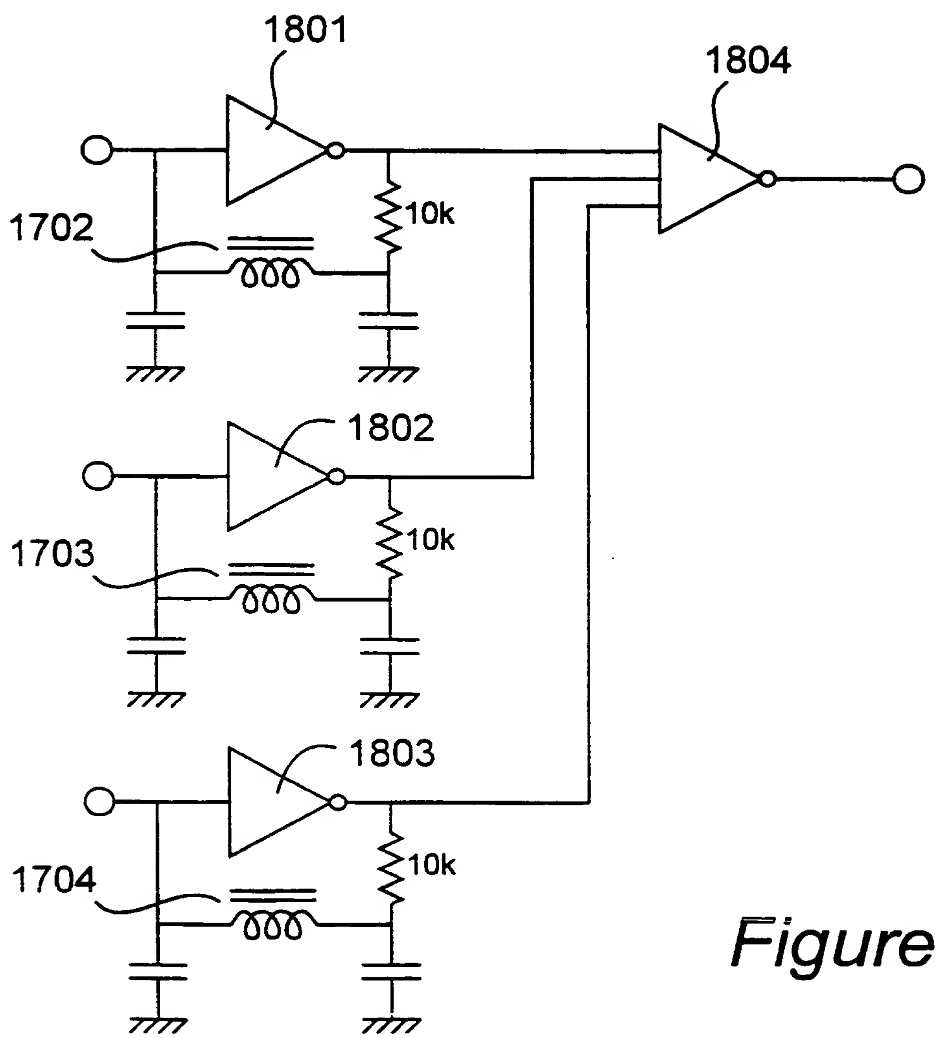


Figure 18

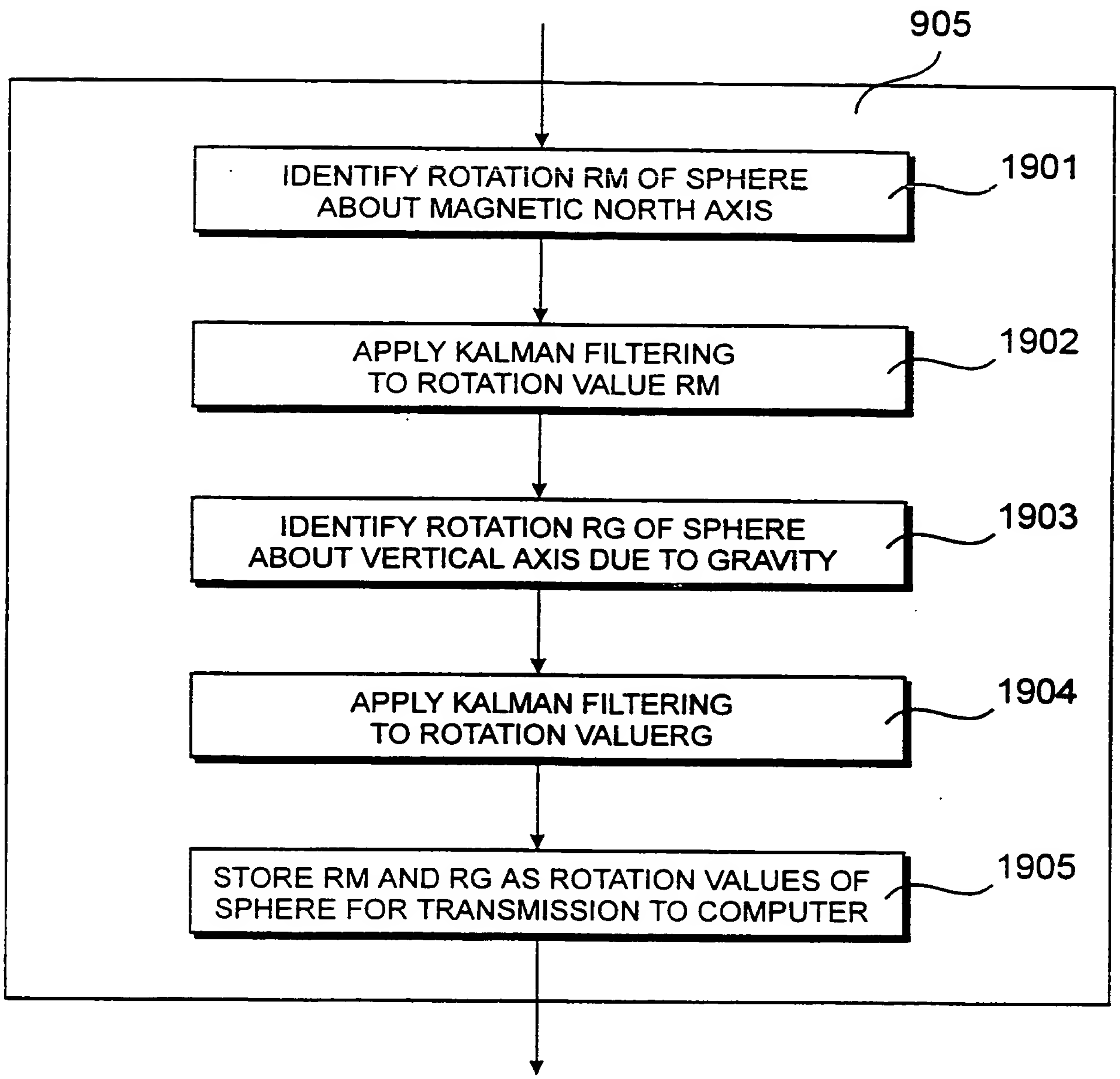

905
IDENTIFY ROTATION RM OF SPHERE ABOUT MAGNETIC NORTH AXIS
1901
APPLY KALMAN FILTERING TO ROTATION VALUE RM
1902
IDENTIFY ROTATION RG OF SPHERE ABOUT VERTICAL AXIS DUE TO GRAVITY
1903
APPLY KALMAN FILTERING TO ROTATION VALUERG
1904
STORE RM AND RG AS ROTATION VALUES OF SPHERE FOR TRANSMISSION TO COMPUTER
1905

Figure 19

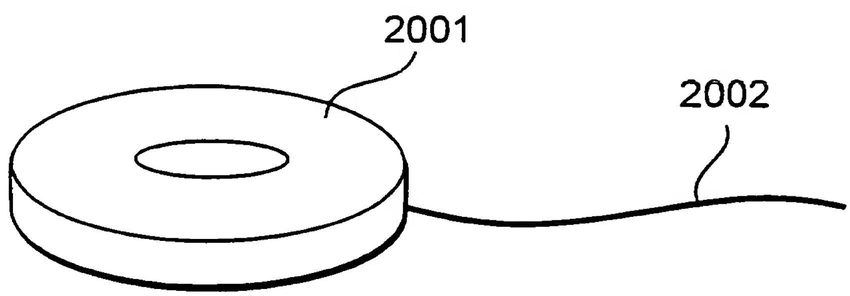


Figure 20

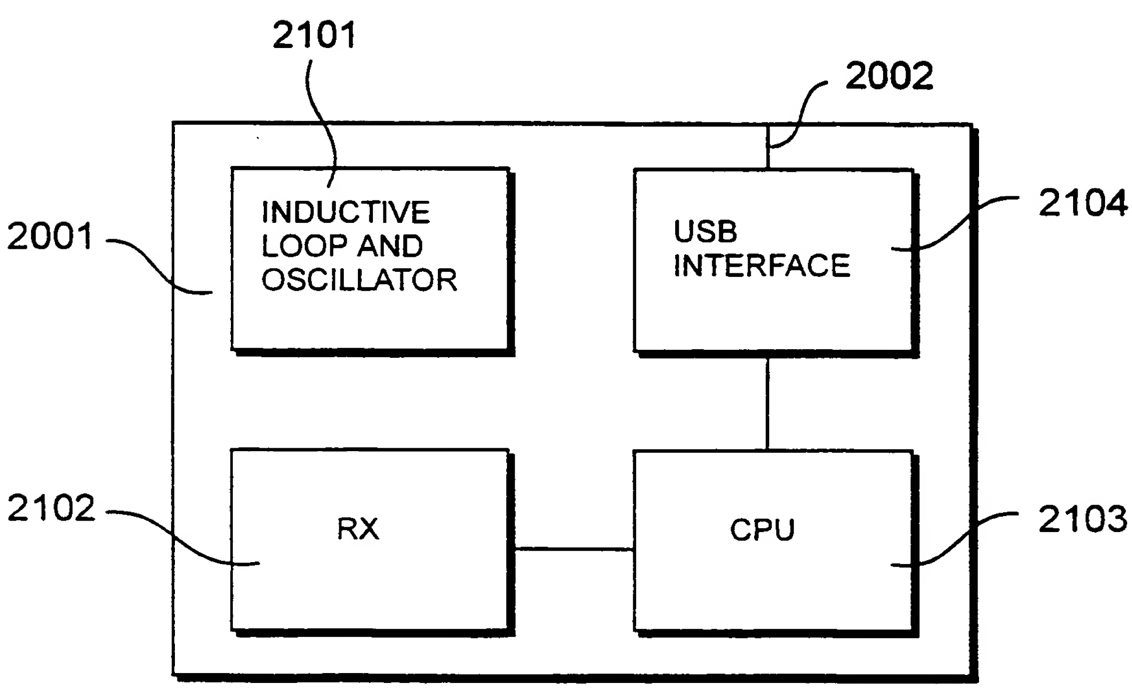


Figure 21

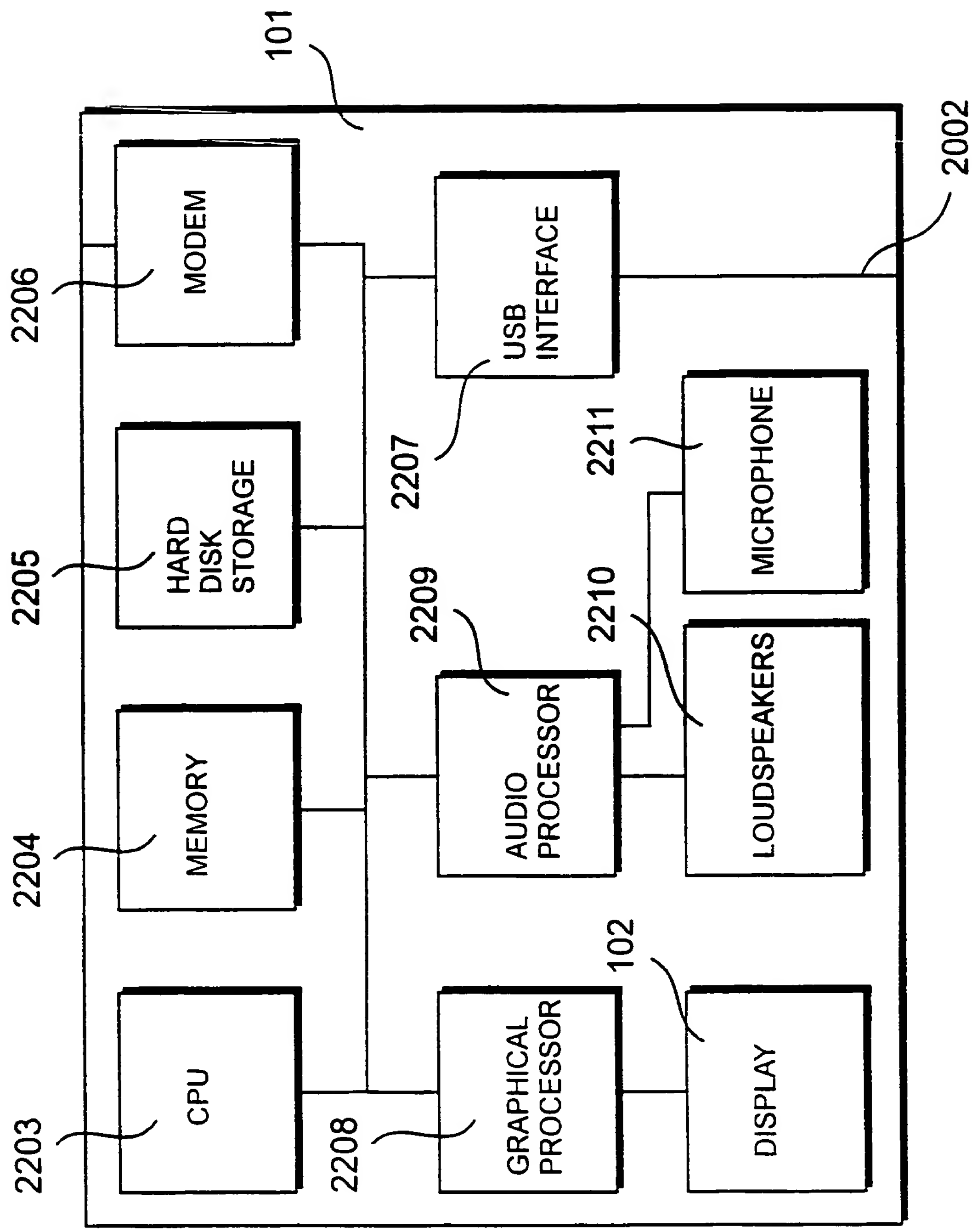

101
2002
2206
MODEM
2205
HARD DISK STORAGE
2204
MEMORY
2203
CPU
USB INTERFACE
2207
2211
MICROPHONE
2209
AUDIO PROCESSOR
2210
LOUDSPEAKERS
2208
GRAPHICAL PROCESSOR
102
DISPLAY

Figure 22

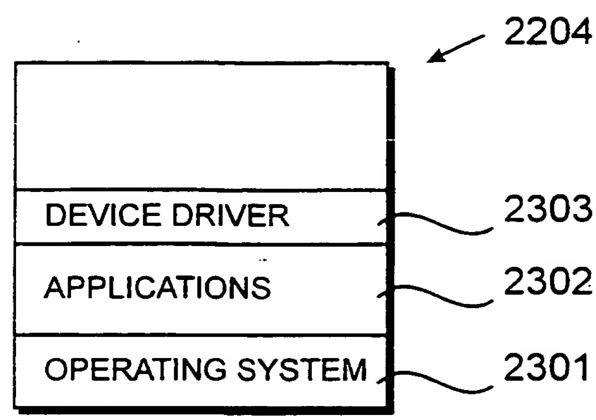


Figure 23

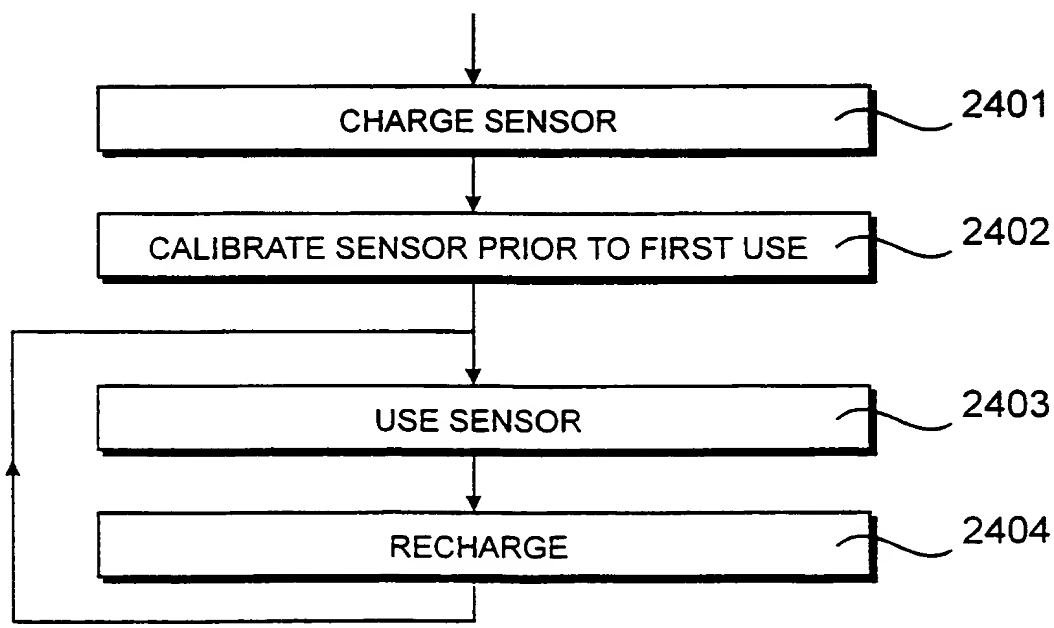


Figure 24

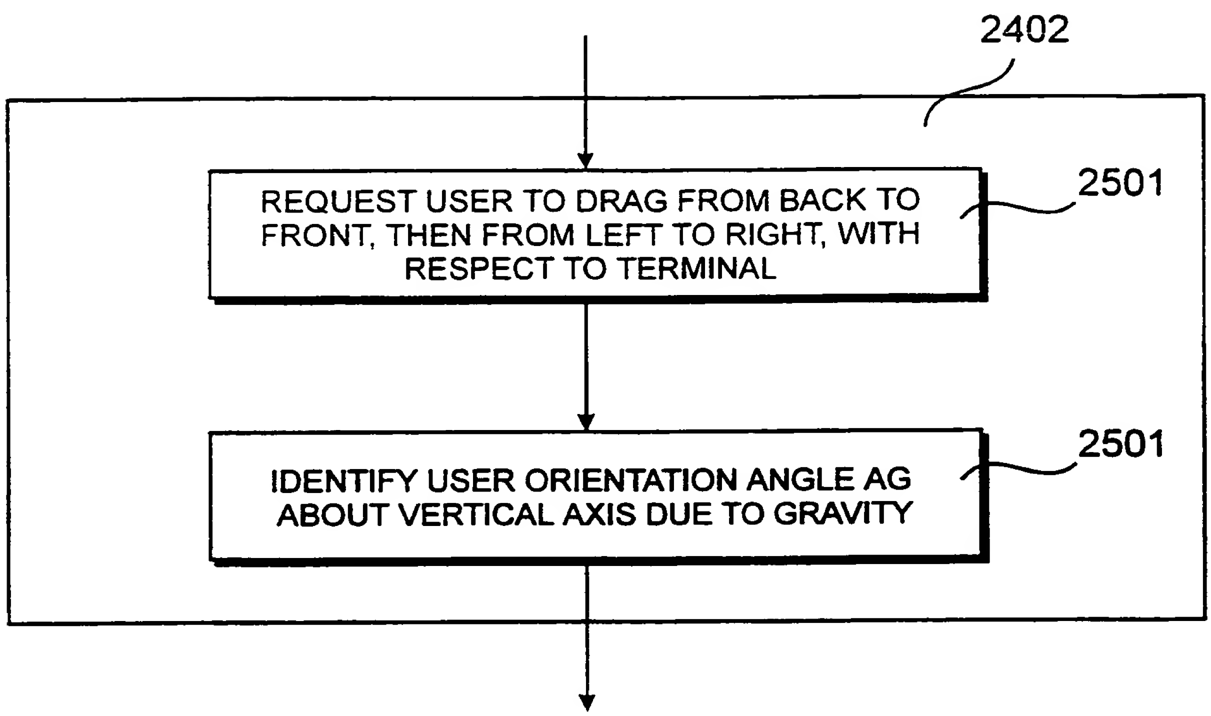

2402
REQUEST USER TO DRAG FROM BACK TO FRONT, THEN FROM LEFT TO RIGHT, WITH RESPECT TO TERMINAL
2501
IDENTIFY USER ORIENTATION ANGLE AG ABOUT VERTICAL AXIS DUE TO GRAVITY
2501

Figure 25

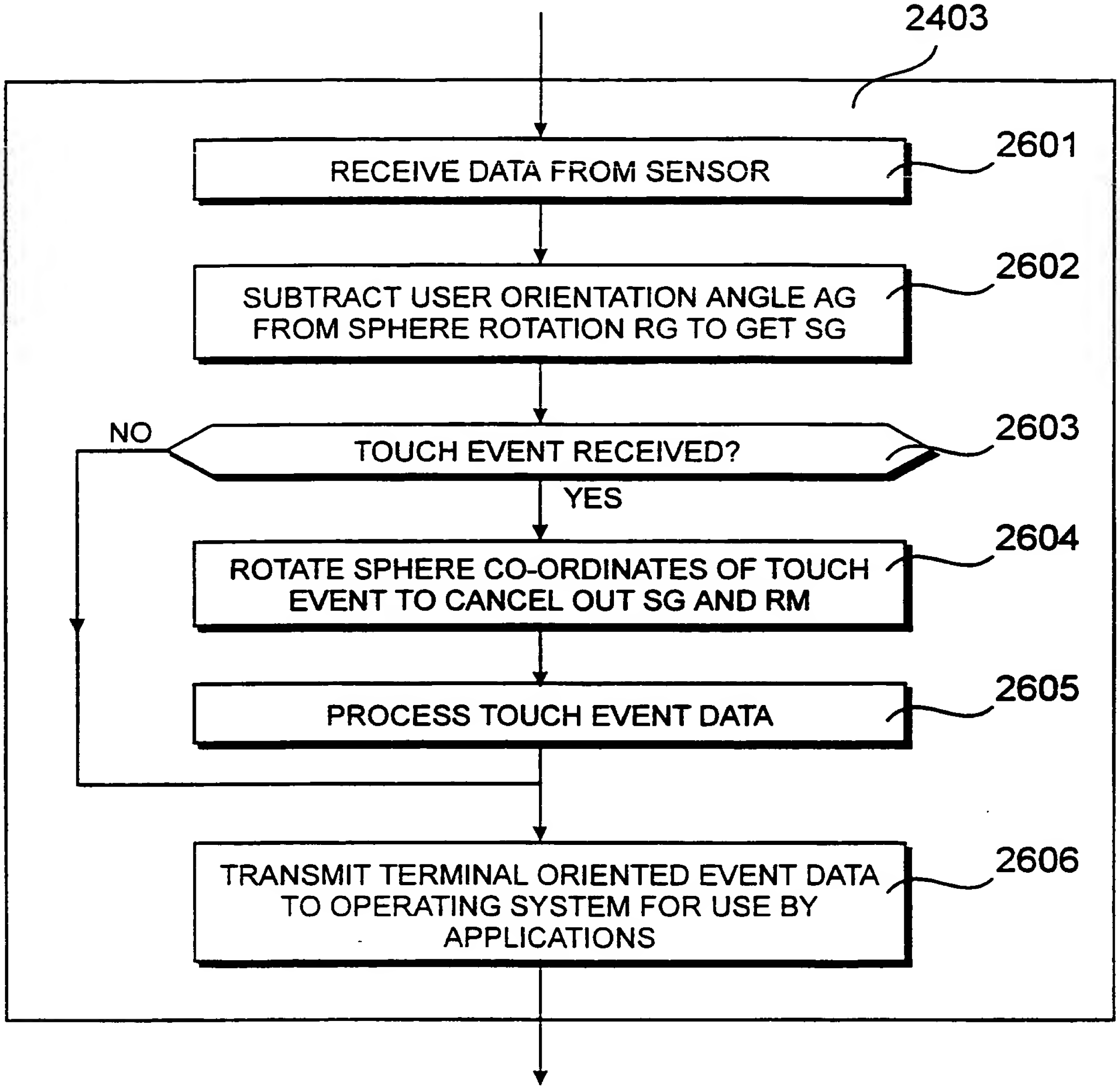

2403
RECEIVE DATA FROM SENSOR
2601
SUBTRACT USER ORIENTATION ANGLE AG FROM SPHERE ROTATION RG TO GET SG
2602
TOUCH EVENT RECEIVED?
2603
NO
YES
ROTATE SPHERE CO-ORDINATES OF TOUCH EVENT TO CANCEL OUT SG AND RM
2604
PROCESS TOUCH EVENT DATA
2605
TRANSMIT TERMINAL ORIENTED EVENT DATA TO OPERATING SYSTEM FOR USE BY APPLICATIONS
2606

Figure 26

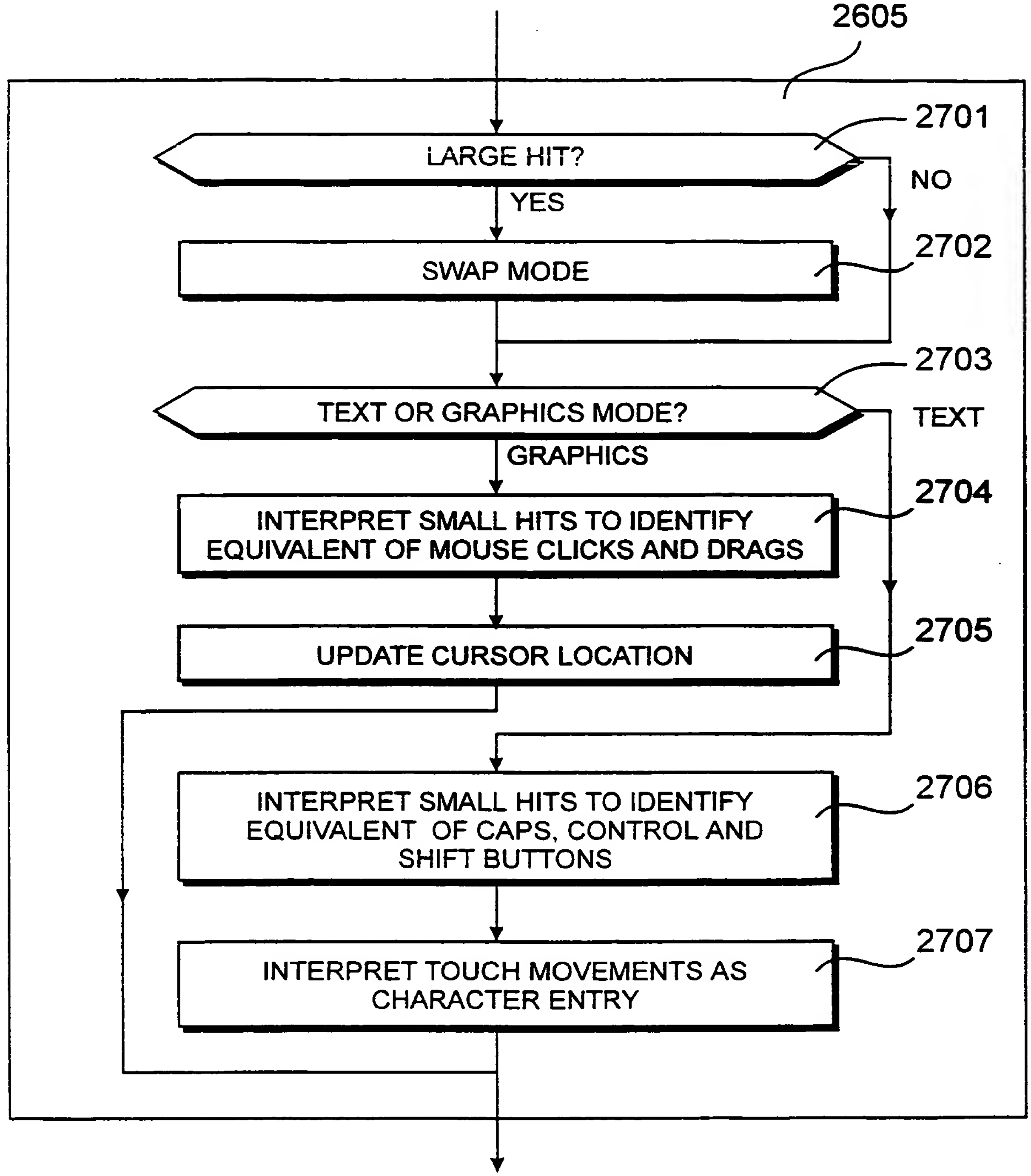

2605
2701
LARGE HIT?
NO
YES
2702
SWAP MODE
2703
TEXT OR GRAPHICS MODE?
TEXT
GRAPHICS
2704
INTERPRET SMALL HITS TO IDENTIFY EQUIVALENT OF MOUSE CLICKS AND DRAGS
2705
UPDATE CURSOR LOCATION
2706
INTERPRET SMALL HITS TO IDENTIFY EQUIVALENT OF CAPS, CONTROL AND SHIFT BUTTONS
2707
INTERPRET TOUCH MOVEMENTS AS CHARACTER ENTRY

Figure 27

INTERNATIONAL SEARCH REPORT

In ational Application No
PCT/GB 00/04635

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G06K11/18 G06K11/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 93 08540 A (STANFORD RES INST INT) 29 April 1993 (1993-04-29) page 2, line 16 - line 38 page 3, line 36 -page 4, line 14 page 4, line 32 -page 5, line 13; claims 1,2,10; figures 1,4	1-4,16, 21
A	WO 97 39401 A (MILGRAM PAUL ;ZHAI SHUMIN (US)) 23 October 1997 (1997-10-23) page 6, line 12 - line 24 page 10, line 21 - line 23; claims 1-3,14-17; figures 1,8	1,2,16, 21
A	US 4 851 775 A (KIM NAM H ET AL) 25 July 1989 (1989-07-25) cited in the application the whole document	3,4,7,8

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 March 2001	14.03.01

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Durand, J

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International Application No
PCT/GB 00/04635

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 526 022 A (DONAHUE MICHAEL J ET AL) 11 June 1996 (1996-06-11) column 2, line 26 - last line; figures 1,4,8	3-5
A	NL 9 300 152 A (RICAR SYSTEMS NEDERLAND B V) 16 August 1994 (1994-08-16) page 3, line 1 - line 24; figures	5-8
A	PATENT ABSTRACTS OF JAPAN vol. 1998, no. 13, 30 November 1998 (1998-11-30) & JP 10 213405 A (GOTO TADATOSHI), 11 August 1998 (1998-08-11) abstract	5-8
A	EP 0 590 830 A (RADIODETECTION LTD) 6 April 1994 (1994-04-06) column 2, line 26 - line 50 column 4, line 19 - line 31; figures 1,6	5-7
A	WO 97 27575 A (PERSONAL INTEGRATED NETWORK NO ;HALL MALCOLM G (US); FAULKNER RUSS) 31 July 1997 (1997-07-31) page 18, last paragraph; figure 9A	9
X	DE 41 43 364 A (KOLLER ROMAN) 30 September 1993 (1993-09-30)	32-34
A	the whole document	10-15, 17,18, 22-29
A	EP 0 474 232 A (SHARP KK) 11 March 1992 (1992-03-11)	10,11, 13-15, 17,22, 32,34
	page 4, line 57 -page 5, line 11 page 5, line 41 - line 43; figures 1,2	
A	PATENT ABSTRACTS OF JAPAN vol. 012, no. 079 (P-676), 12 March 1988 (1988-03-12) & JP 62 216025 A (SONY CORP), 22 September 1987 (1987-09-22) abstract	10,17, 22,32,34
A	PATENT ABSTRACTS OF JAPAN vol. 1995, no. 09, 31 October 1995 (1995-10-31) & JP 07 141094 A (HITACHI LTD;OTHERS: 01), 2 June 1995 (1995-06-02) abstract	10,17, 22,32,34

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2

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 049 862 A (DAO JAMES ET AL) 17 September 1991 (1991-09-17) column 7, line 49 - line 56 column 8, line 44 - line 56 ---	19
A	US 5 063 600 A (NORWOOD DONALD D) 5 November 1991 (1991-11-05) column 10, line 21 - line 57 ---	19
A	GB 2 314 470 A (WANG JACK ;TIEN CHUNG LUNG (TW); WANG HUEI MING (TW)) 24 December 1997 (1997-12-24) the whole document ---	20
A	US 5 666 473 A (WALLACE MICHAEL G) 9 September 1997 (1997-09-09) the whole document -----	30,31

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 00/04635

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [ ] Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. [X] Claims Nos.: 35,36
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. [X] As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[X] No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-4,16,21

   input device with touch and orientation sensing

2. Claims: 5-9

   input device orientation sensing with respect to gravity

3. Claims: 10-15,17,18,22-29,32-34

   input device with sound actuated touch detectors

4. Claim : 19

   input device connected to a computer switching between text and graphical mode

5. Claim : 20

   input device with rechargeable cell

6. Claims: 30,31

   spherical touch input device mapped to a three dimentional object

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 35,36

Rule 6.2(a) PCT: Claim refering to other parts of the application

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.